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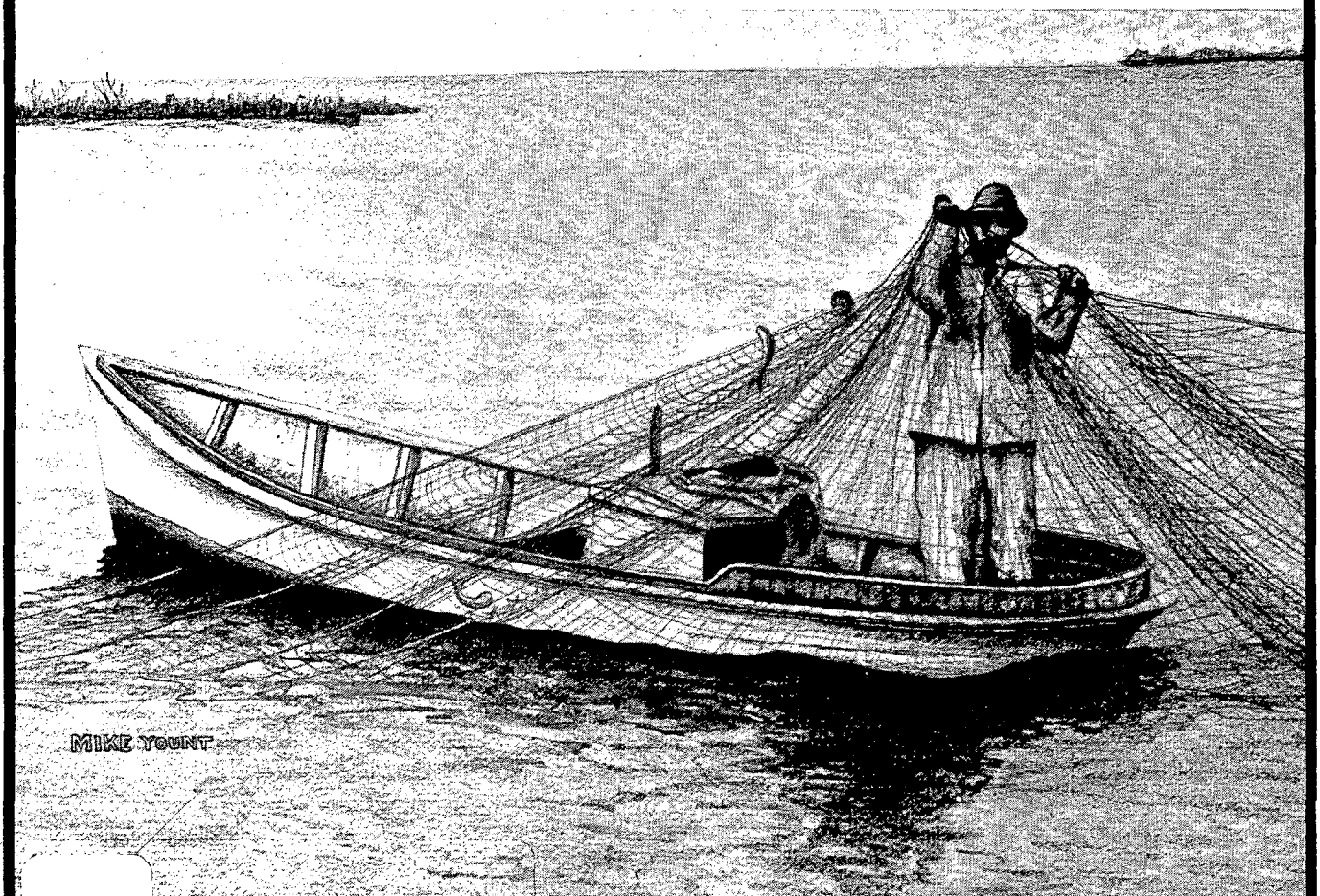
INVESTIGATIONS of ANADROMOUS FISHES of the NEUSE RIVER, NORTH CAROLINA



DIVISION OF MARINE FISHERIES
NORTH CAROLINA DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT

INVESTIGATIONS OF ANADROMOUS FISHES

of the

NEUSE RIVER, NORTH CAROLINA

by

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and Community Development
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ABSTRACT

Investigations were made into the life histories of blueback herring, alewife, hickory shad, American shad, striped bass, and Atlantic sturgeon in the Neuse River, North Carolina. Sampling began on 1 June 1976 and extended to 20 September 1979, utilizing wing trawls, flat trawls, seines, planketon nets, and gill nets. Spawning areas were identified in the Neuse River for blueback herring, alewife, hickory shad, American shad, and striped bass. Growth of blueback herring was determined for the 1976-1979 year classes. Growth of American shad juveniles was determined on the 1977-1979 year classes. Juvenile relative abundance was determined for blueback herring during 1977-1979. Year class composition and spawning repetition was determined for adult blueback herring, alewife, hickory shad and American shad. Striped bass year class composition was also determined for the same year. Tagging studies were conducted on blueback herring, alewife, American shad, hickory shad, striped bass and Atlantic sturgeon providing information on adult migration in the Neuse River.

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TABLE OF CONTENTS

INTRODUCTION

Anadromous fishery resources have historically made important contributions to North Carolina's total commercial finfish harvest. During 1960-70, anadromous fish landings accounted for 49 percent of the total edible finfish landings in North Carolina (Table 1). However, for 1971-79, anadromous species comprised only 20 percent of the edible finfish landings. Two obvious reasons for the decline in anadromous fish landings are increases in commercial effort for and harvest of non-anadromous finfish, and a decline in landings of certain anadromous species during the same period. American shad and river herring landings have decreased considerably from the catches of 1965-69-a period which produced the greatest poundage of both species during the last 25 years.

Anadromous fish also contribute significantly to the recreational fishery in North Carolina's estuaries and tributaries. Although no specific landings are available, the recreational harvest is estimated to be in the millions of pounds (Sholar 1977).

A total of seven species are considered to be anadromous in North Carolina: American shad *(Alosa sapidissima)*, hickory shad *(Alosa mediocris)*, blueback herring *(Alosa aestivalis)*, alewife *(Alosa pseudoharengus)*, striped bass *(Morone saxatilis)*, Atlantic sturgeon *(Acipenser oxyrhynchus)*, and shortnose sturgeon *(Acipenser brevirostrum)*. Blueback herring and alewife are considered collectively as river herring. The shortnose sturgeon has not been identified in North Carolina in recent years and may be extinct within the state (Schwartz and Link 1976).

All the major tributaries of North Carolina's coastal sounds support commercial and recreational fisheries for anadromous species. The major American shad streams are the Neuse, Tar-Pamlico, Cape Fear, Northeast Cape Fear, and Chowan Rivers (Figure 1). The Neuse and Tar-Pamlico Rivers produce the largest landings of hickory shad in North Carolina (Marshall 1977). River herring are the most abundant anadromous fishes, and are widely distributed along the coast in major and minor tributaries. Striped bass are found in North Carolina's coastal waters year-round, ascending all major rivers to spawn. Sturgeon are caught commercially and recreationally in most of the major coastal tributaries.

Table 1. Relative importance of anadromous fish in North Carolina and in the Neuse River area as shown by commercial landings (National Marine Fisheries Service and Division of Marine Fisheries data).

Year	Total edible finfish (lb)	Anadromous fish(lb)	Percent anadromous	Anadromous fish (lb), Neuse River	Percent anadromous, Neuse River
1960	30,470,000	14,308,000	47.0	173,200	1.2
1961	30,029,000	13,490,000	45.0	262,700	1.9
1962	31,887,000	16,037,000	50.3	225,700	1.4
1963	32,344,000	16,864,000	52.1	190,700	1.1
1964	24,548,000	9,182,000	37.4	209,800	2.3
1965	33,639,000	14,658,000	43.6	325,900	2.2
1966	32,567,000	14,129,000	43.4	202,868	1.4
1967	40,880,000	21,248,000	52.0	143,900	0.6
1968	33,377,000	18,467,000	55.3	136,500	0.7
1969	36,657,000	22,281,000	60.8	189,700	0.8
1970	29,832,000	14,974,000	50.2	106,600	0.7
1971	31,379,000	14,991,000	47.8	134,400	0.9
1972	40,731,000	13,190,000	32.4	87,900	0.6
1973	41,203,000	10,121,000	24.6	87,640	0.9
1974	49,244,000	7,730,000	16.4	63,950	0.8
1975	53,681,000	7,570,000	14.1	37,100	0.5
1976	53,754,000	7,671,000	14.3	45,900	0.6
1977	61,642,000	9,417,000	15.0	9,200	>0.1
1978	75,166,000	7,759,000	10.3	37,346	0.5
1979	82,462,714	6,043,120	7.3	31,600	0.5

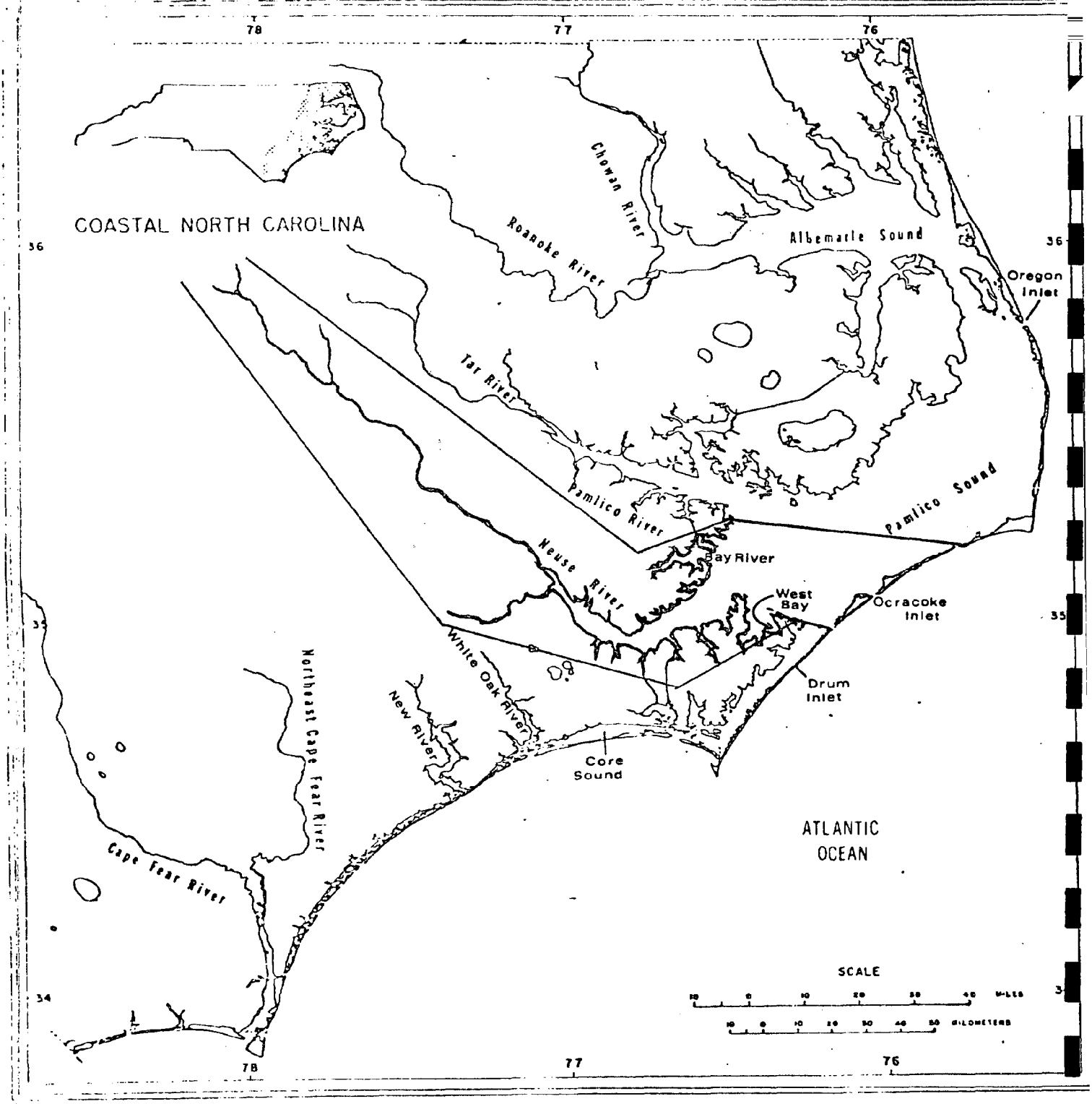


Figure 1. - Neuse River Basin

The North Carolina Division of Marine Fisheries, in cooperation with the National Marine Fisheries Service and the U S Fish and Wildlife Service, is conducting studies in all the major coastal river systems of North Carolina to obtain data needed to manage anadromous fish resources. These programs are designed to provide key information enabling optimum utilization of anadromous species. Little specific information was available for this purpose prior to the initiation of the anadromous study programs. The objectives of the North Carolina Division of Marine Fisheries are to identify anadromous fish spawning and nursery areas, determine migration periods and routes, investigate distribution and relative abundance, and determine year class composition of adult stocks. Investigations of this type have been conducted in the Albemarle Sound area, Tar-Pamlico River, and northern Pamlico Sound, New River, White Oak River, and Northeast Cape Fear River (Figure 1). Studies are presently being conducted on the Neuse and Cape Fear Rivers, and in the Albemarle Sound area. This report presents the results of a three year study on anadromous species in the Neuse River.

STUDY AREA

The Neuse River Basin, encompassing an estimated area of 1,603,666 ha is the second largest drainage basin lying entirely within North Carolina. The Neuse River, formed by the confluence of the Eno and Flat Rivers northeast of Durham, has an estimated drainage area of 1,449,826 ha. The river flows in a generally southeasterly direction from its origin to Wilkinson Point below New Bern, where the estuary turns to flow eastward into Pamlico Sound (Figures 2 and 3). Bay River and Core Sound from Ocracoke Inlet to Drum Inlet were also included in the Neuse River Basin by Bayless and Smith (1962).

The Neuse River and its tributaries drain all or a portion of eighteen counties. The upper third of the river lies within the Piadmont Region of North Carolina, with the fall line occurring halfway between Raleigh and Smithfield (Figure 2). The Piedmont tributaries are usually swift and turbid, flowing through relatively deep valleys and narrow flood plains. The waters of the Coastal Plain, which comprise the remaining two-thirds of the river basin, are dark and slow-moving. The average stream gradient within this region is only .6 foot (.18m) per mile (Bayless and Smith 1962).

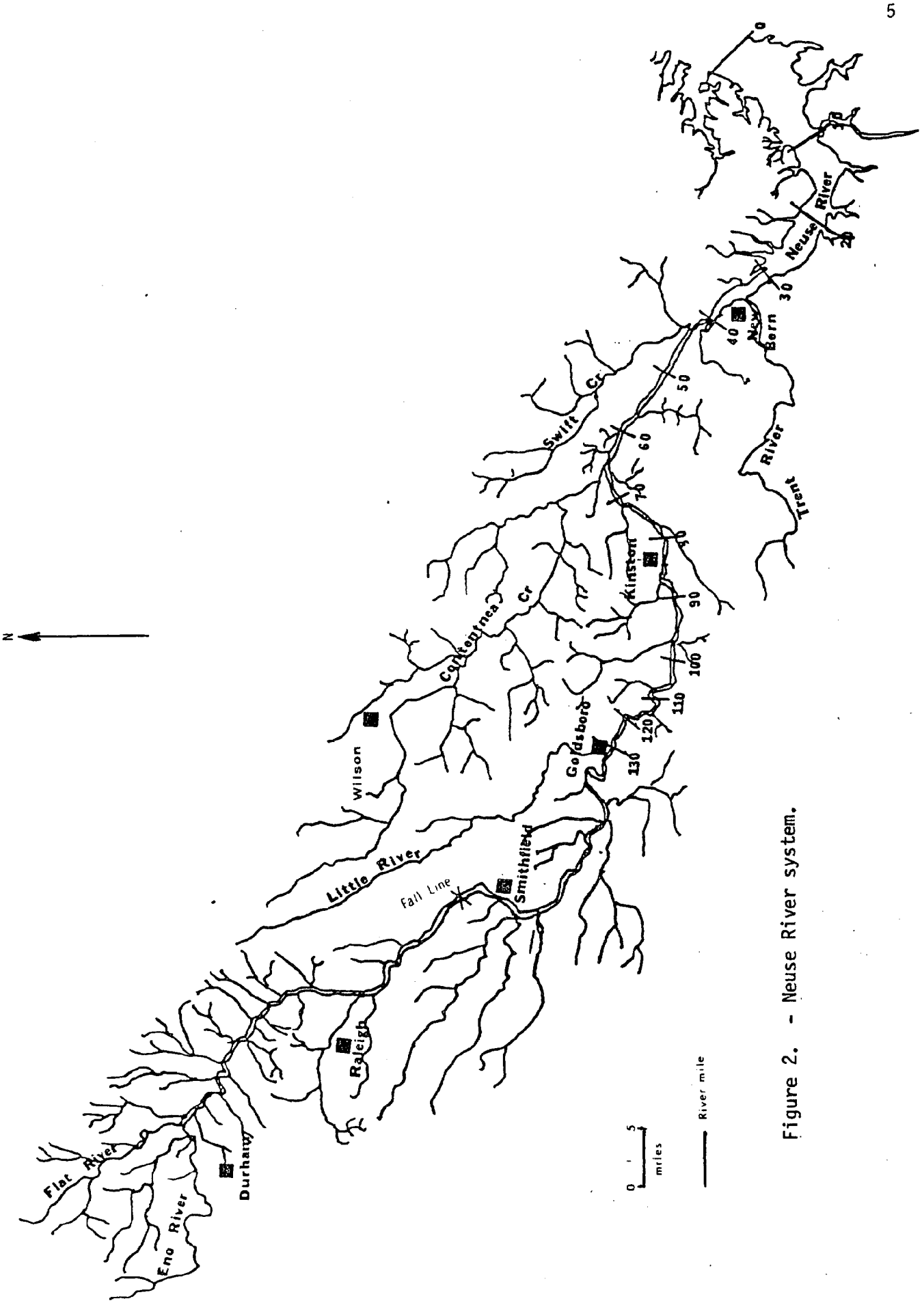


Figure 2. - Neuse River system.

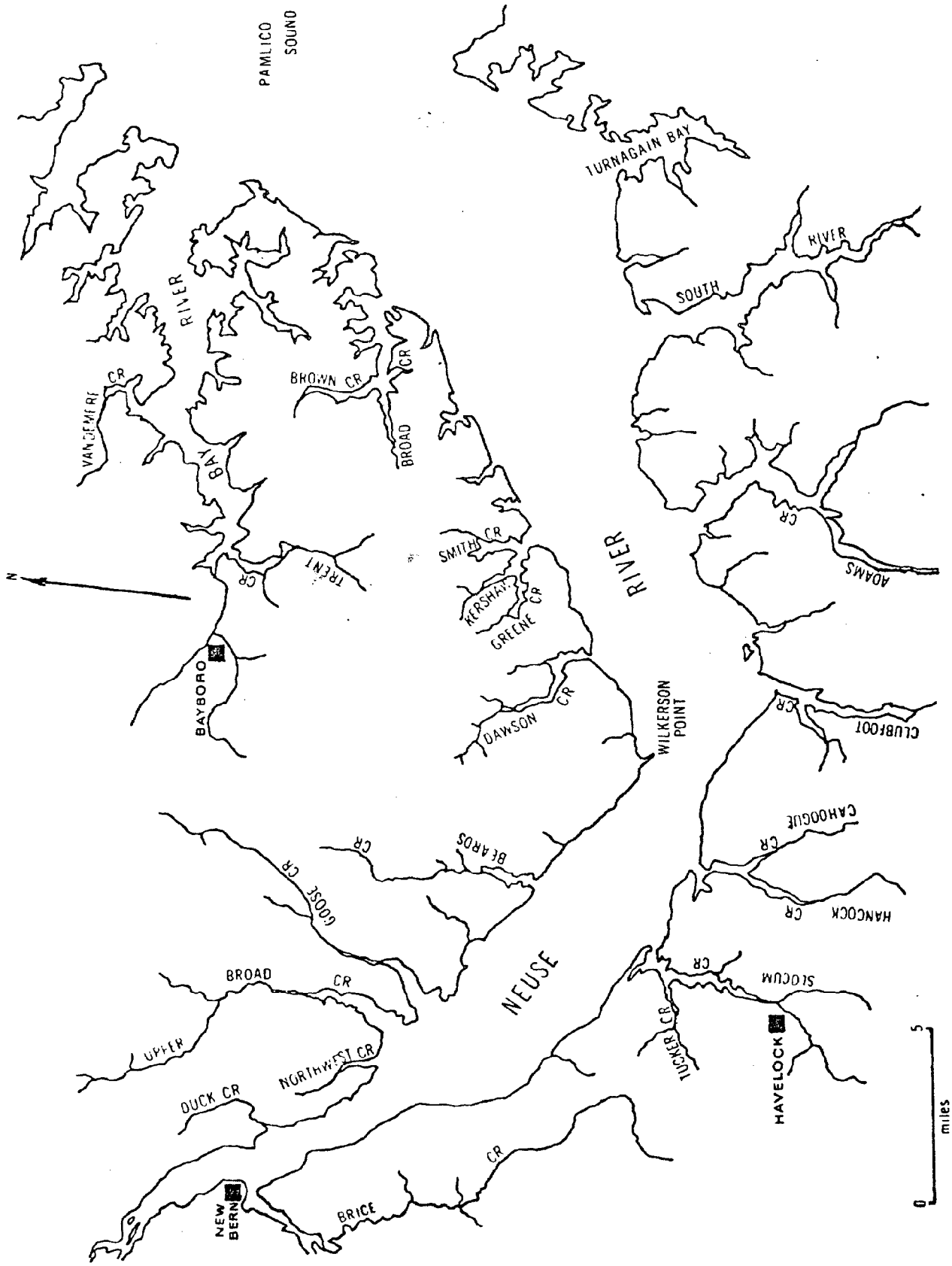


Figure 3. - Major tributaries of the Neuse River, North Carolina

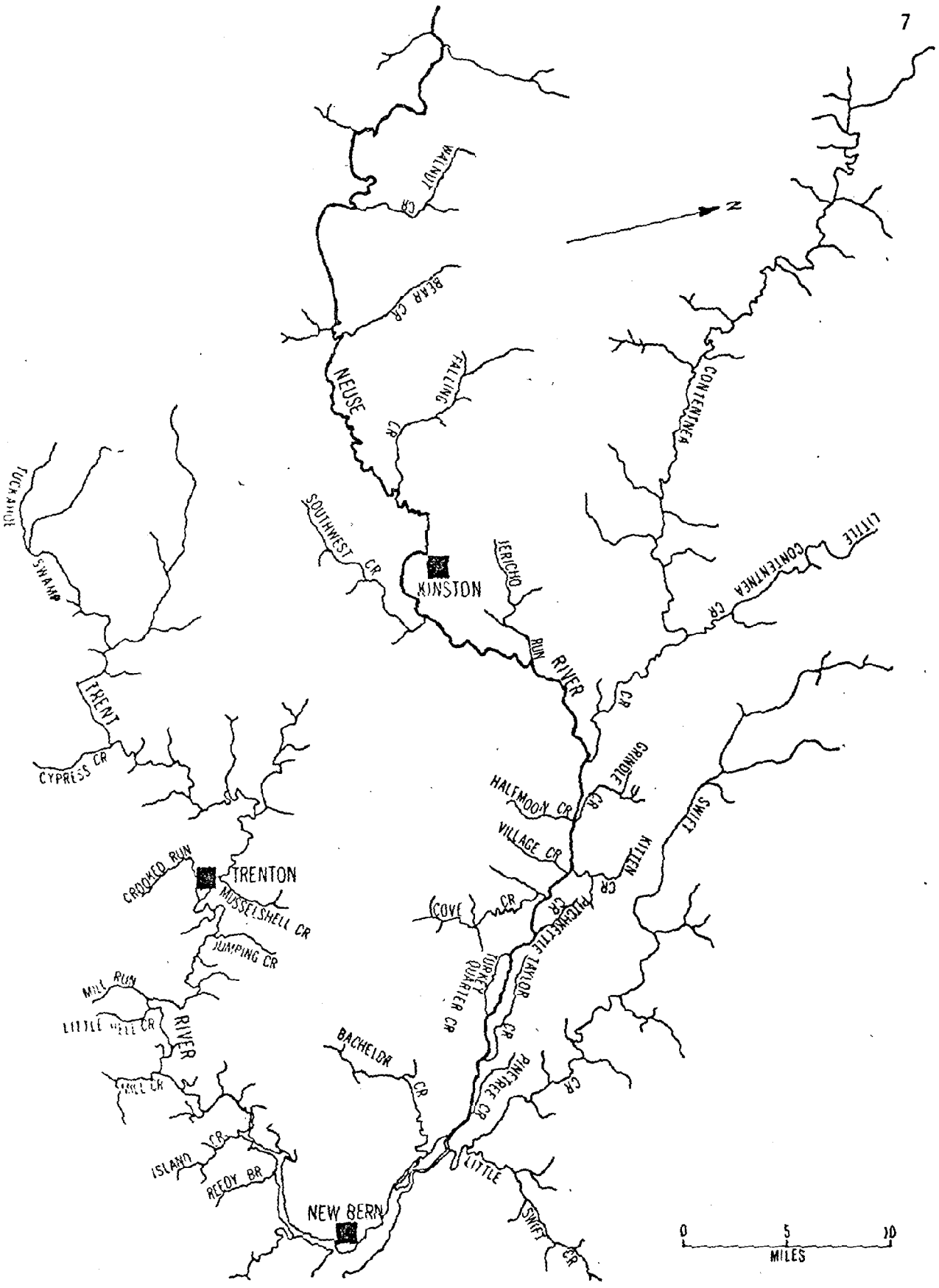


Figure 3. - continued

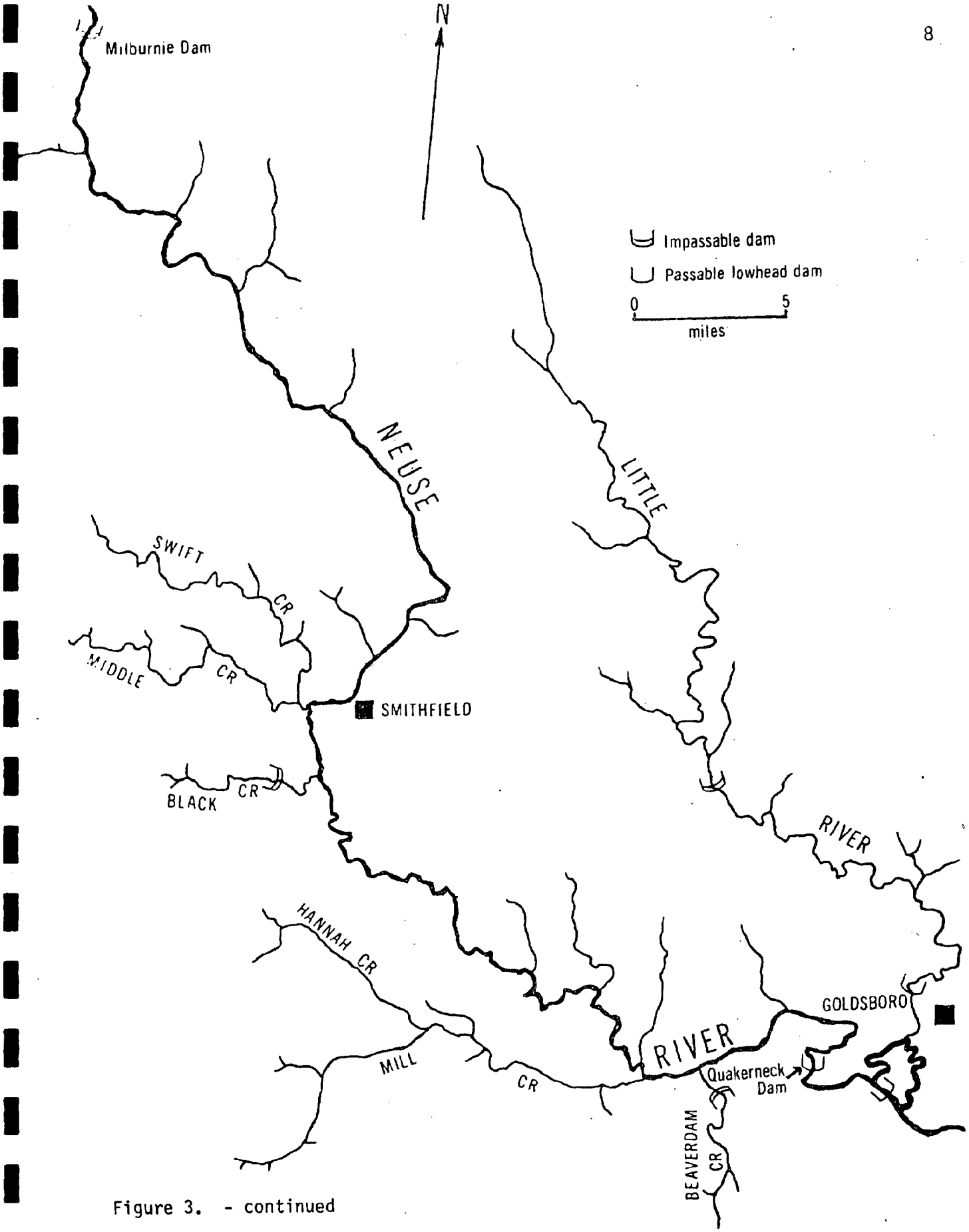


Figure 3. - continued

The Neuse River Basin enjoys a moderate climate averaging 61°F (16°C) year-round. Much of the land is under silvicultural and agricultural use. There are seven urban areas within the basin: Durham, Raleigh, Wilson, Goldsboro, Kinston, New Bern, and Smithfield. The basin also offers a wide variety of excellent hunting and fishing activities (NC State Board of Health 1959).

The principal tributaries of the Neuse River from its mouth to New Bern are: Broad Creek, Turnagin Bay, South River, Smith and Greene Creek, Adams Creek, Dawson Creek, Clubfoot Creek, Hancock Creek, Beards Creek, Slocum Creek, Goose Creek, Upper Broad Creek, and Trent River, the largest tributary of the Neuse.(Figure 3). All of these tributaries lie within 34 mi (55 km) of the mouth of the river.

The principal tributaries between New Bern and Goldsboro are Batchelor Creek (the best sport fishing stream in the Neuse-Bayless and Smith 1962),Swift Creek, Cove Creek, and Contentnea Creek. These creeks are all within 64 mi (103 km) of the Neuse River mouth. Contentnea Creek, at river mile 64 (103 km) is the last major tributary until Little River is reached above Goldsboro at river mile 134 (216 km). Above Little River, the only major tributaries are the Flat and Eno Rivers which join to form the Neuse.

There are two low-head dams (approximately 12 ft (3.7m) high) on the Neuse River between Raleigh and the river mouth: Milburnie Dam near Raleigh and Quaker Neck Dam at Goldsboro. Milburnie Dam is an inoperative mill dam, while Quaker Neck Dam impounds cooling water for the Carolina Power and Light Steam Plant near Goldsboro. Five additional small dams are found in the Goldsboro-Smithfield area; two on Little River, one in the Army Corps of Engineers' constructed waterway joining two sections of the Neuse below Quaker Neck Dam, on Beaverdam Creek, and the other on Black Creek (Figure 3).

LITERATURE REVIEW

Street and Hall (1973) compiled a bibliography concerning anadromous fish in North Carolina that provided reference to all previous research conducted on these species in the Neuse River through 1972. Bayless and Smith (1962) described the streams in the Neuse River Basin, reporting several occurrences of anadromous fish in the tributaries of the Neuse. Documentation of anadromous fish nursery areas in the lower Neuse River appeared in a report by Spitsbergen and Wolff (1974).

Baker (1968) estimated the recreational harvest of striped bass, American shad, river herring, and hickory shad from coastal North Carolina, finding that the Neuse River is the major stream for the recreational harvest of American shad and hickory shad. He also collected striped bass, Americal shad, and river herring eggs in the Neuse River. Tobaben (1971) briefly described tagging operations for striped bass in the lower Neuse River. Walburg (1957) did an intensive study on total catch, fishing effort, fishing rate, size of spawning run, and spawning escapement of American shad for the Neuse River in 1953.

Several aspects of the life history of hickory shad in the lower Neuse River were reported by Pate (1972). LaPointe (1958) studied the age and growth rates of American shad in the Neuse River. Nichols (1966) found that rivers on the Atlantic coast, including the Neuse, contained discrete populations of juvenile American shad. Migration of American shad in the Neuse and several other Atlantic coast rivers was reported by Sykes and Talbot (1959). Walburg and Nichols (1967) wrote an extensive report of the Atlantic coast American shad fishery, describing each state's recreational and commercial fishery for particular river systems.

Keup and Bayless (1964) recorded the relationship of several anadromous species to varying salinities in the Neuse River. An investigation of reduced oxygen tolerance and petroleum toxicity of American shad juveniles from the Neuse River was conducted by Tagatz (1961).

MATERIALS AND METHODS

Spawning Area Sampling

Potential spawning areas were sampled during early March to late May in the Neuse River. Gill nets were utilized in the mainstream and tributaries to capture adults, and to determine the limits of upstream migration in the Neuse. Capture of running ripe adult females was regarded as one criterion for classifying river sections as spawning areas. Ten, twenty, and forty meter units of 63.5 mm (2.50 in), 69.9 mm (2.75 in), 82.6 mm (3.25 in), 101.6 mm) 4 in), 123.7mm (4.88 in), and 139.7 mm (5.50 in)stretched mesh monofilament gill net were set for 24 hr periods. Fork length (Fl, mm) measurements were recorded on all captured adult anadromous fish. Each anadromous fish was examined to determine sex and spawning condition, and scale samples were taken for age determination and evidence of previous spawning.

Eggs and larvae were sampled with a 0.5 m plankton net of #00 Nitex mesh, with a wide mouth (0.95 l) jar attached to the cod end. Plankton net sampling was conducted from early March until late May. Sample times were 15 minutes when taken from either a bridge or stationary boat. Plankton nets were also towed for five minutes at a very low speed when there was insufficient current for a stationary set. One unit of sampling effort consisted of either one minute of stationary sampling or one minute of towed sampling.

Water chemistry data, including dissolved oxygen, pH, and temperature,were recorded with each sample. Samples were preserved in 5% formalin and returned to the laboratory where eggs and larvae were sorted, identified, counted, and measured. When the numbers of eggs or larvae of particular anadromous species were large, a random subsample of thirty was measured, and the rest counted. All eggs and larvae were measured with a binocular microscope fitted with either an ocular micrometer or micrometer disc.

Nursery Area Sampling

During the spring of 1976 suitable nursery area sampling sites were selected in the Neuse River through preliminary sampling. A total of 104 sites was investigated, with 48 selected for regular sampling. Both seine (8) and trawl(40)stations were sampled monthly from June-December, 1976-77. The total station number was decreased to 37 during 1978-79, with 9 seine and 28 trawl stations being sampled monthly (figure 4).

The seine stations were pulled with a 60 ft (18.3 m) bag seine fitted with a 1/4 in (6.3mm) bar mesh bag. One seine haul was considered one unit-of-effort. All trawl stations during 1976-77 were sampled with a 26 ft (7.9 m) head rope wing trawl containing webbing which ranged from 4 in (101.6 mm) stretched mesh in the wings to 1/4 in (6.3 mm) in the tail bag (Street et al. 1975). The wing trawl was fitted with surface doors to avoid underwater obstructions. During 1978-79 only inland trawl stations (21) were sampled with the wing trawl. These stations were located on the Trent River and on the Neuse River above New Bern.

In 1978-79 estuarine trawl stations in the Neuse River were separated into primary and secondary stations according to the nursery area classification by Purvis (1976) and Spitsbergen and Wolff (1974). The primary trawl stations (5) were pulled with a 13 ft (3.96 m) head rope flat trawl composed of 1/4 in

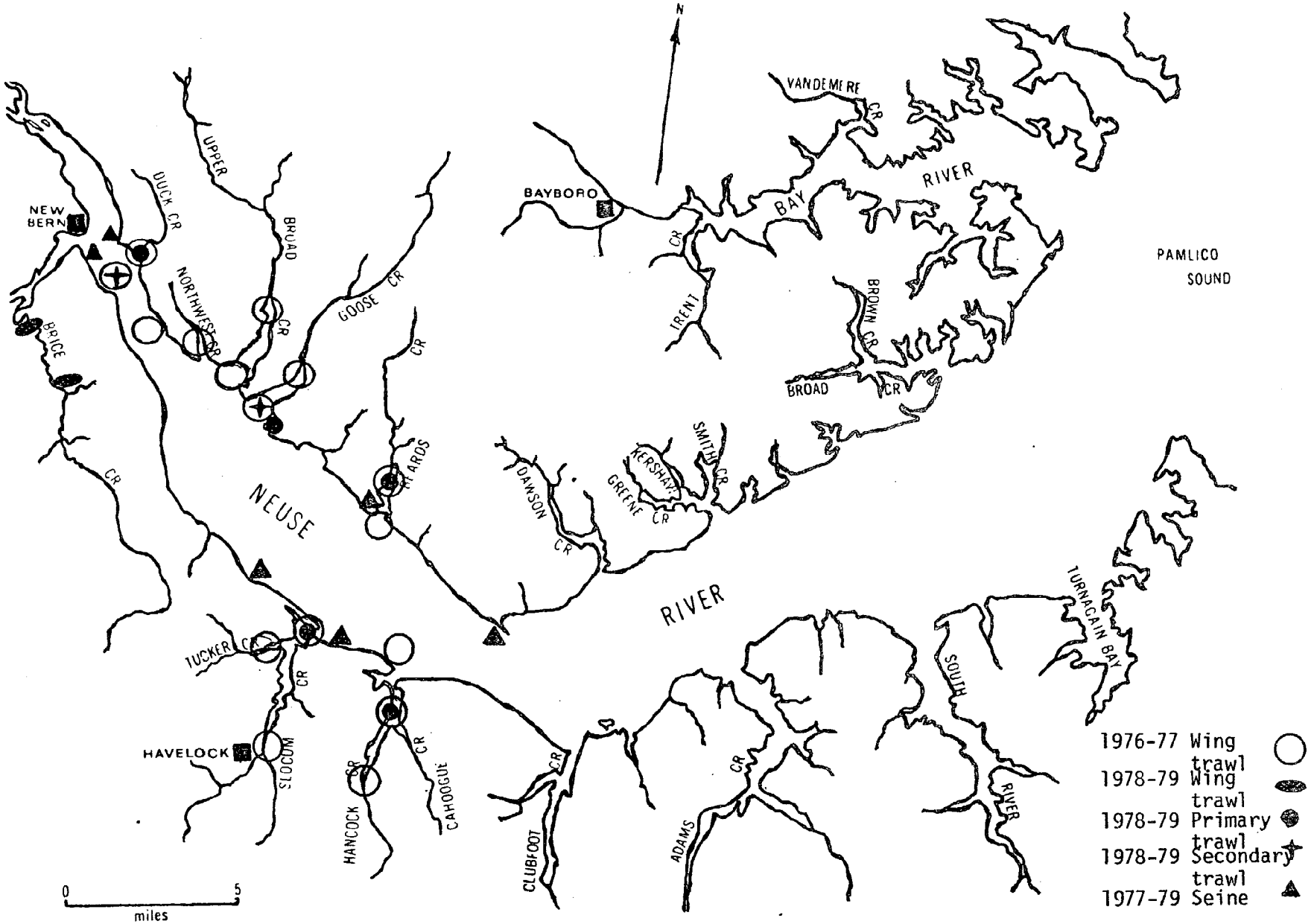


Figure 4 - Monthly (May-December) juvenile sampling stations in the Neuse River, NC, 1976-79.

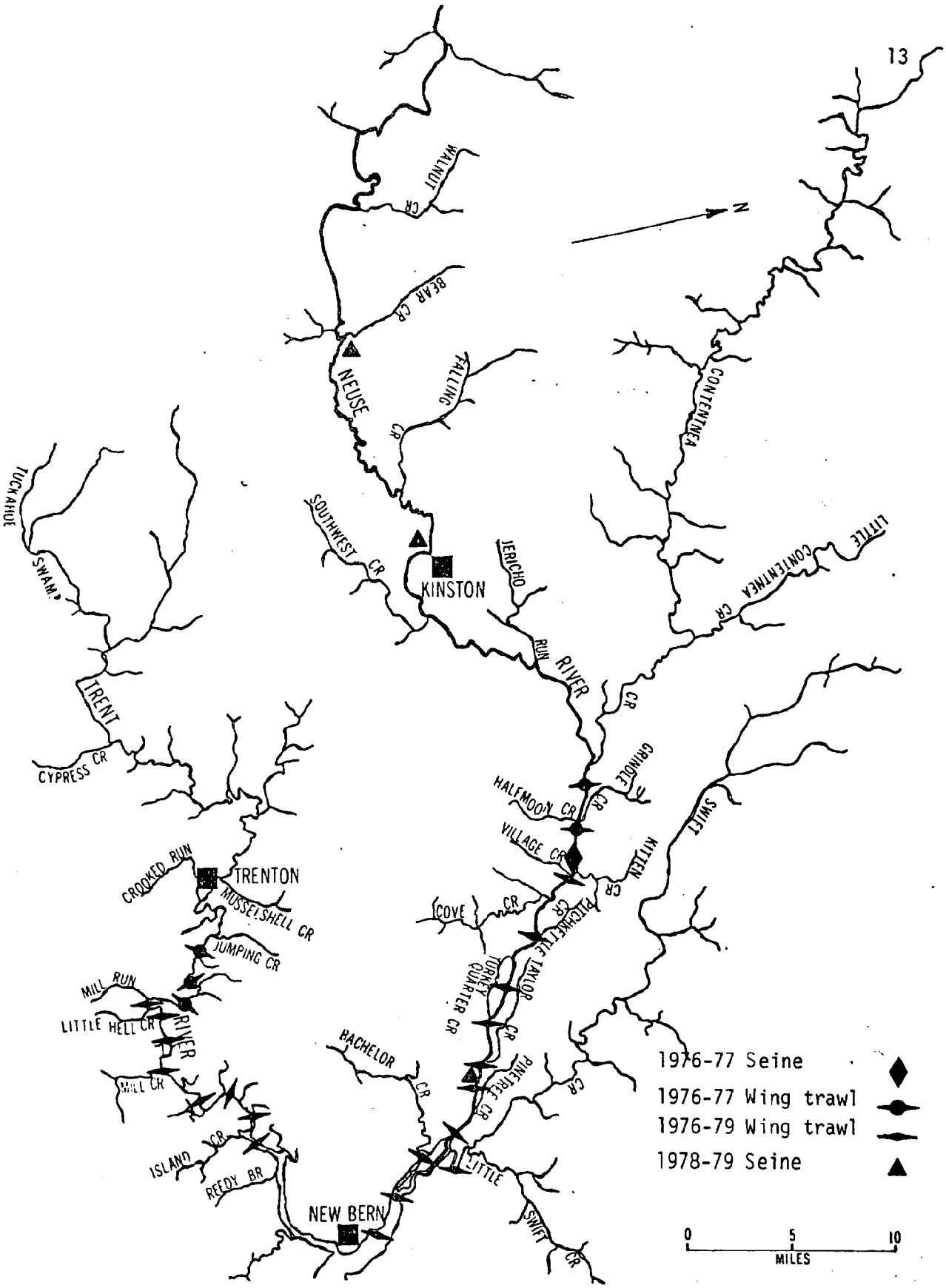


Figure 4 - continued

(6.3 mm) bar mesh knotted wings and body, with a 1/8 in (3.2 mm) bar mesh knitted tail bag. Secondary stations (2) were sampled with similar gear, except that the bar mesh was 3/4 in (19.2 mm) in the wings and tail bag, and the head rope was 21 ft (6.4 m) long. Both trawls were fitted with bottom towing doors.

Wing trawl stations were pulled for five minutes at 1800 revolutions per minute (rpm) by a 17 foot (5.2 m) boat equipped with an 85 horsepower outboard engine. Primary nursery area stations were sampled for one minute at 1900 rpm, and secondary stations, five minutes at 2200 rpm with the same boat. A one minute tow was considered one unit-of-effort.

All species were identified and counted in each sample, with a maximum of 30 fish per species measured at each station. Water temperature and salinity were measured with a salinity-conductivity meter.

Adult Fish Harvest

Adult anadromous fish landings were sampled at seven locations along the lower Neuse River to determine species composition, sex ratios, and age-class structure of anadromous fishes (Figure 5). Each sample site was visited weekly beginning in mid-February. Sampling ended when catches dropped to a level which did not warrant sampling. The principal gear utilized in the lower Neuse River was staked gill nets, set primarily for striped bass and American shad. The principal species sampled in these areas was American shad; however, a few striped bass, hickory shad, and river herring were encountered. Samples taken at these locations were considered to be representative of the catches in each area. Very few unculled samples were available to determine species composition and sex ratios.

A haul seine, located upstream on the Neuse River near Pitchkettle Creek was also visited regularly during the fishing season in 1976-77. In 1978 the seine was moved near the SR 1470 bridge. The haul seine provided small unculled catches of American shad and river herring.

Fork lengths of adults were measured to the nearest millimeter. Scales of clupeids were taken from the left side, below the insertion of the dorsal fin, and just above the mid-line as suggested by Rothschild (1963) and Marcy (1969). Striped bass scales were taken just behind the tip of the pectoral fin. As suggested by Cating (1953), twenty scales were taken from each fish to avoid loss

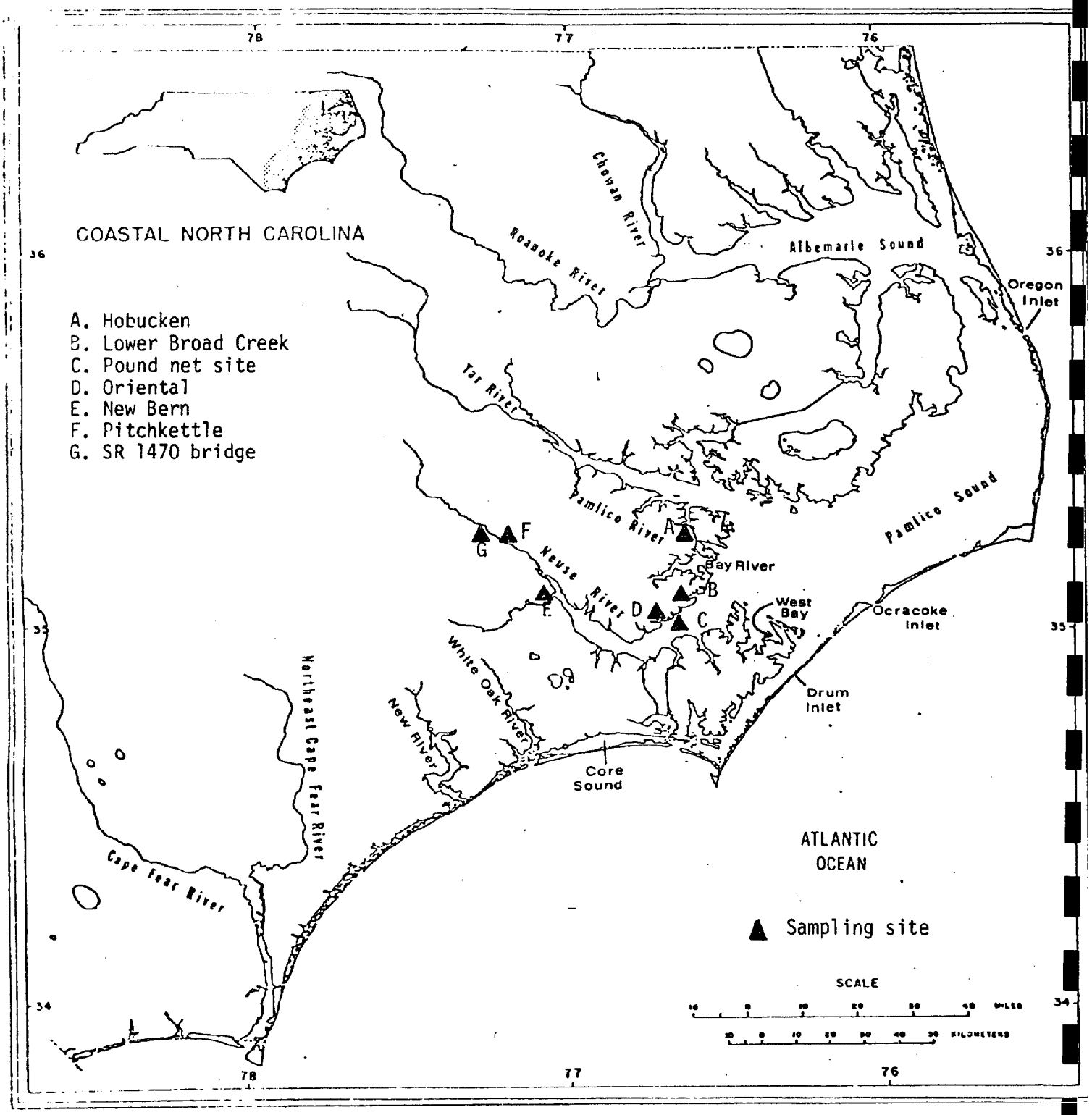


Figure 5. - Location of Neuse River commercial fish sampling sites.

of data due to high incidence of regenerated scales. Scales were read on a microfiche reader at 24X magnification. At least three of the most legible scales were read from each fish. The scale edge was counted as a year mark, as it was assumed that each fish had completed a full year's growth at the time of capture.

Tagging

Two separate tagging programs were conducted during 1976-79 on the Neuse River: (1) from January through April, 1977-79, all captured anadromous fish in suitable condition were tagged in the lower and middle Neuse River and tributaries, and (2) during October through December, 1976-79, striped bass were tagged in the middle Neuse River.

Fall striped bass tagging was accomplished by the drop net method described by Tobaben (1971) and Marshall (1976). Drops were made in the Neuse River just above New Bern with a net 365.7 m (400 yd) long, composed of 101.6 mm (4 in) stretched monofilament nylon webbing. The drop net was fished two ways: (1) the net was deployed in a U-shaped pattern encircling a point of land, and (2) the net was dropped along an area where pilings or other bottom obstructions existed. In both cases a disturbance was created in the drop net area to drive fish into the net. This method was most effective at night when there was little wind.

Staked gill nets were set during January-March, 1977-79 to capture anadromous fish for tagging during their spring spawning migration. These nets were composed of the same mesh sizes as those previously described under "spawning area sampling." Nets were fished daily and checked early each day to ensure maximum survival.

A pound net was set during late winter and early spring 1979 near Greene Creek (Figure 5) for tagging purposes. The pound net consisted of a 273.4 m (300 yd) lead composed of 152.4 mm (6 in) stretched mesh which connected to a pound made of 101.6 mm (4 in) stretched mesh. The net was checked daily from February to late March.

A rented haul seine was also utilized as a tagging device during mid-March through April, 1977-79. The seine was located near Pitchkettle Creek in 1977 and near the SR 1470 bridge in 1978-79 (Figure 6). The haul seine was checked weekly when river conditions were favorable.

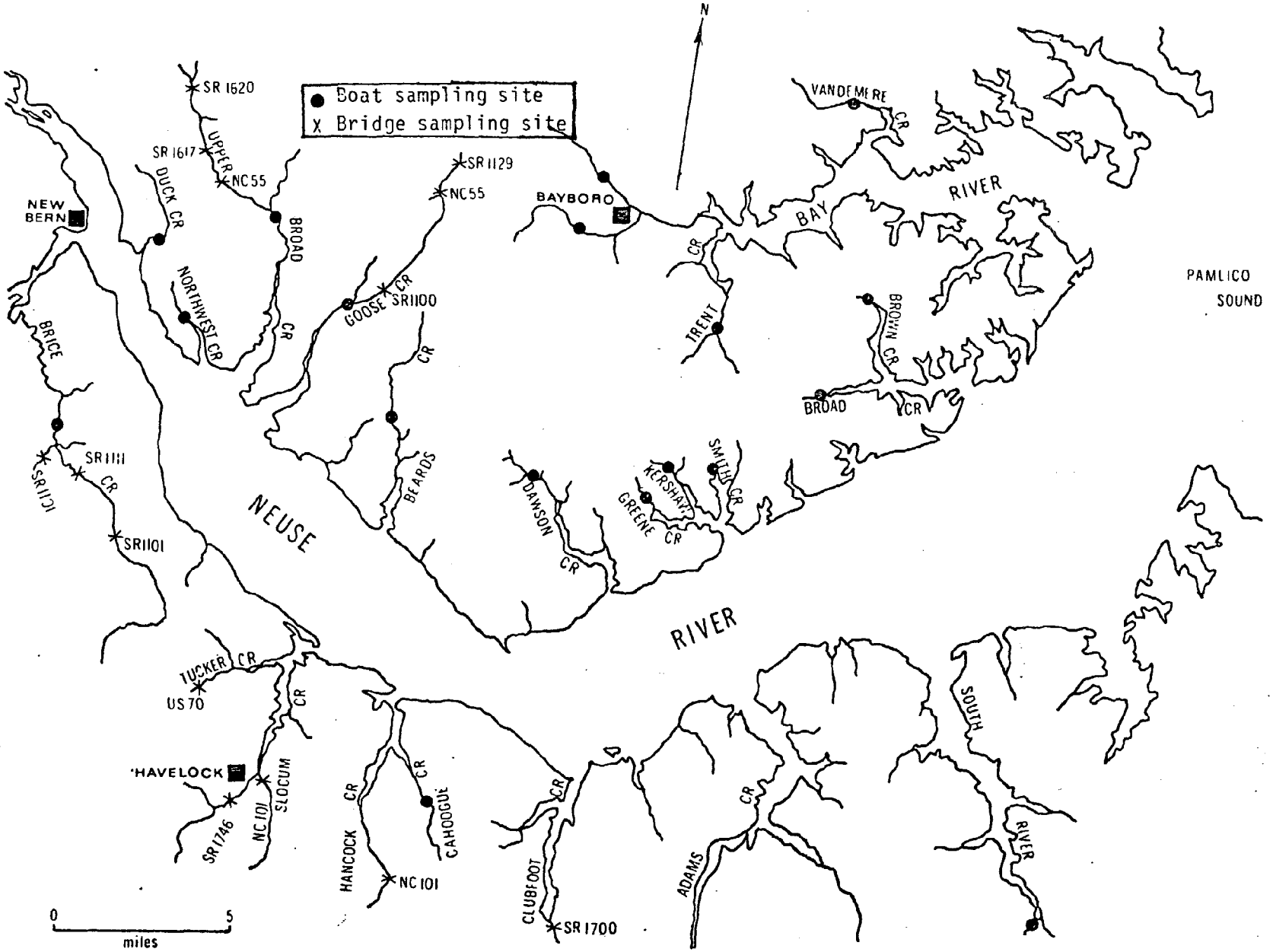
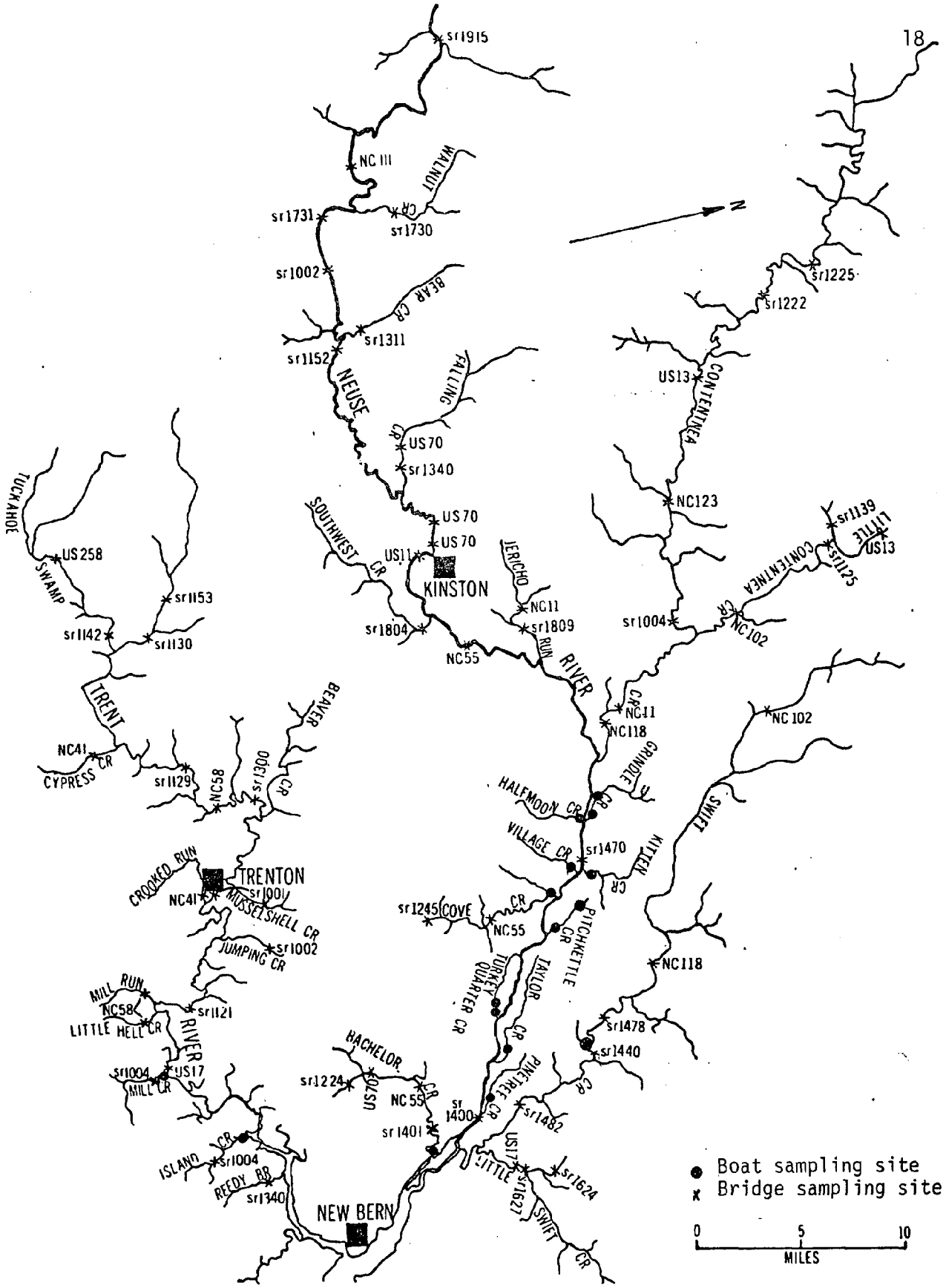


Figure 6. Sampling sites for spawning area survey in the Neuse River NC, 1977-79.



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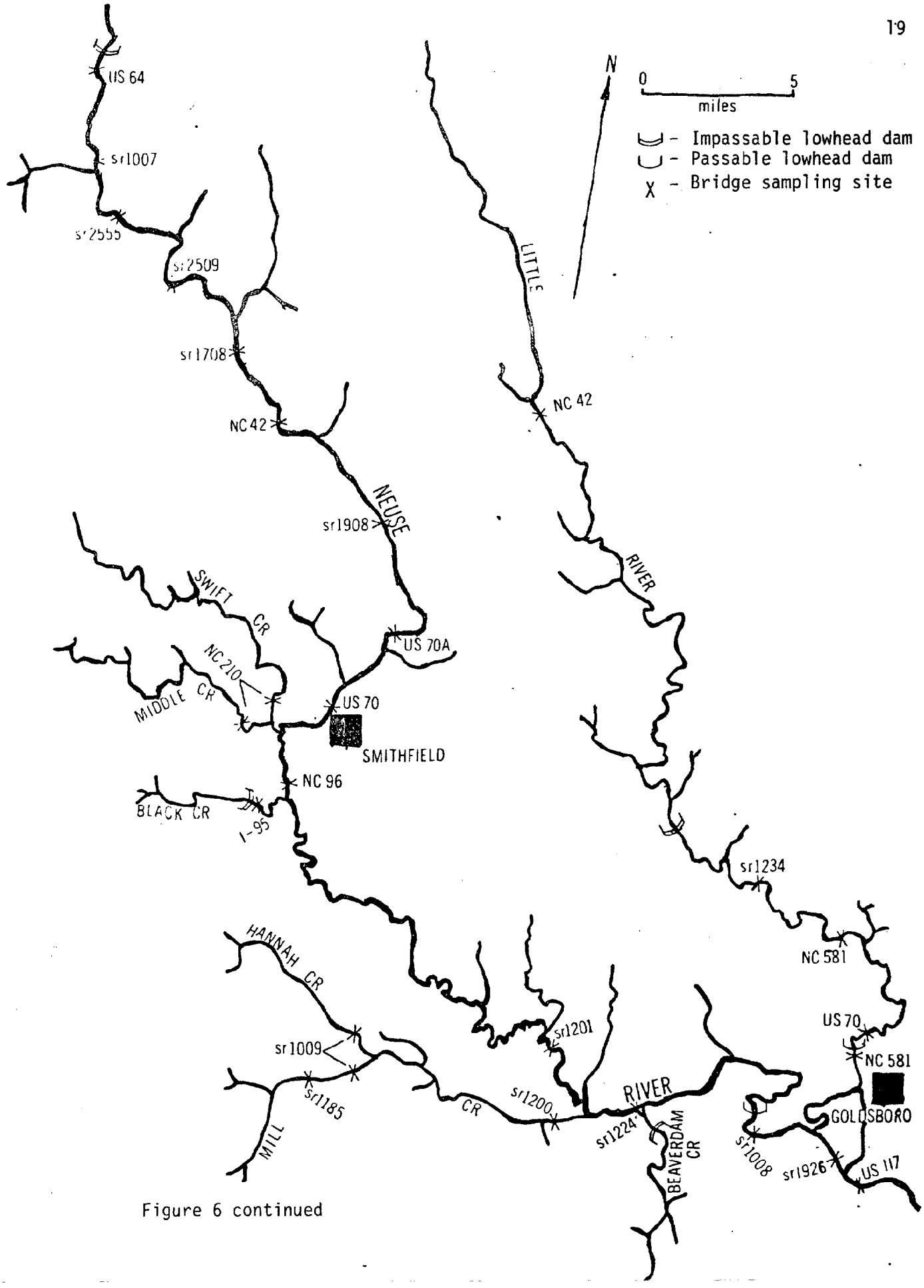

Figure 6 continued

All fish were tagged with Floy FD-68B anchor tags placed below the insertion of the dorsal fin. Each fish was measured (Fl, mm) and scales taken for age determination. The tagging program was publicized by placing posters throughout the study area. Rewards of $1.00, $5.00, $10.00 and $25.00 were offered for returned tags.

RESULTS AND DISCUSSION

Spawning Areas

Designation of spawning areas in the Neuse River and tributaries were based on occurrence of only one or more of the following criteria: (1) observation of spawning activity, (2) capture of running-ripe females, and/or (3) capture of eggs or recently-hatched larvae. Lippson and Moran (1974) and Mansueti and Hardy (1967) provided criteria for identification of eggs and larvae. Eggs and larvae of blueback herring and alewife are reported together as river herring because of the difficulty in accurately separating early developmental stages of these two species. However, gill net sampling showed that about 85% of the river herring captured in the Neuse River and its tributaries were blueback herring. Sampling during the initial segment of this project showed a general mixing of blueback herring and alewife in the lower Neuse River. Spawning area sampling sites are shown in Figure 6. Results of egg net sampling in the Neuse River and tributaries are summarized in Table 2. Table 3 shows where running-ripe female river herring, American shad, and hickory shad were taken, as well as locations where spawning activity was observed during 1977-79. A total of 8,683 minutes of sampling resulted in the capture of 1,518 eggs and 457 larvae of anadromous fish during March - May 1977-79. Eggs and larvae of all the anadromous species except sturgeons were taken. Eggs and larvae of many other species were taken in addition to anadromous fishes: pickerels, suckers, minnows, yellow perch, centrachids, and others.

River herring

River herring spawned in the Neuse River and tributaries from 15 March to 30 May during the three year study. Water temperatures during spawning ranged from 11° - 26°C, pH from 6.4 - 8.9, and dissolved oxygen levels from 4 - 12 parts per million (ppm). Most river herring spawning occurred in the smaller tributaries and flooded low-lying areas adjacent to the main section of the river.

Table 2. - Location and results of egg net samples in the Neuse River and its tributaries, 1977-1979.

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Slocum Creek	SR 1746	155	Herring	80	0.32	5	0.03
	NC 101	15	Herring	3	0.2		
Tucker Creek	US 20	15	No catch				
Hancock Creek	NC 101	25	Herring	2	0.08		
	Cahoogue Creek	5	No catch				
Clubfoot Creek	SR 1700	30	No catch				
South River		15	No catch				
Duck Creek		20	No catch				
Northwest Creek		15	No catch				
Upper Broad Creek	SR 1620	15	No catch				
	SR 1617	15	No catch				
	NC 55	45	No catch				
	Boat Sampling site	60	Herring	55	0.92		
Goose Creek	SR 1129	15	No catch				
	NC 55	30	No catch				
	SR 1100	15	No catch				
	Boat Sampling site	75	No catch				
Beards Creek		40	Herring	5	0.13		
Dawson Creek		40	Herring	96	2.40		
	NC fork	5	Herring	1	0.20		
Greene Creek		15	No catch				
Kershaw Creek		60	Herring	14	0.23		
Smith Creek		20	Herring	17	0.85		

Table 2. - (continued)

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Broad Creek		30	No catch				
	Brown Creek	40	No catch				
Bay River	South prong	20	No catch				
	North prong	20	No catch				
	Trent Creek	10	Herring	2	0.20		
	Vandemere Creek	15	No catch				
Trent River (Mainstem)	US 17	45	No catch				
	SR 1121	15	Herring	1	0.07		
	SR 1001	90	Herring	4	0.04		
			American shad	1	0.01		
			Hickory shad	1	0.01		
	SR 1300	75	Herring			2	0.03
	NC 58	105	No catch				
	SR 1129	45	Herring	1	0.02		
	SR 1130	45	No catch				
	SR 1153	75	Herring	5	0.07	1	.013
Brice Creek	SR 1101	80	No catch				
	SR 1111	60	Herring	32	0.53		
	Boat Sampling site	60	Herring	4	0.07		
Reedy Branch	SR 1340	15	No catch				
Island Creek	SR 1004	115	No catch				
Island Creek	Mouth	5	No catch				
Mill Creek	SR 1004	75	Herring	18	0.24		
	Mouth	5	No catch				

Table 2. - (continued)

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Little Hell Creek	NC 58	30	No catch				
Mill Run	NC 58	90	Herring	18	0.20	14	0.2
Jumping Creek	SR 1002	15	Herring	1	0.07		
Crooked Run	NC 41	45	No catch				
Musselshell Creek	SR 1001	15	No catch				
Beaver Creek	SR 1316	30	No catch				
Cypress Creek	NC 41	30	No catch				
Tuckahoe Swamp	SR 1142	60	No catch				
	US 258	30	No catch				
Neuse River (Mainstem)	SR 1400	80	Herring	0		4	.05
	SR 1470	65	Herring	6	.09	5	.08
	NC 55	135	Herring	160	1.19		
			Striped bass	22	.16		
			American shad	1	.01		
			Hickory shad	1	.01		
	US 70 Business	155	Herring	24	.15	2	.01
	Kinston		American shad	1	.01	1	.01
	US 70 Bypass	90	Herring	2	.02	1	.01
	Kinston		Striped bass	6	.07		
			American shad	1	.01		
	NC 11	105	Herring	2	.02	1	.01

Table 2. - (continued)

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Neuse River (Mainstem)	NC 11	105	Striped bass	1	.01		
			American shad	2	.02	4	.04
	SR 1152	195	Herring	2	.01		
			Striped bass	13	.07	1	.01
			American shad	3	.02		
	SR 1002	150	Herring	2	.01		
			Striped bass	57	.38		
			American shad	2	.01	2	.01
			Hickory shad	2	.01		
	SR 1731	130	Herring			1	.01
			Striped bass	89	.68		
			American shad	6	.05		
			Hickory shad	4	.03		
	NC 111	105	Herring	141	1.34		
			Striped bass	4	.04		
			American shad	1	.01		
	SR 1915	135	Herring	5	.04		
			Striped bass	10	.07		
			American shad	2	.01	2	.01
	US 117	45	No catch				
	SR 1926	30	American shad	1	.03	1	.03
	SR 1008	120	Herring	1	.01	1	.01
			American shad	1	.01	1	.01
	SR 1224	205	Striped bass	1	.01		
			American shad	2	.01	2	.01
	SR 1201	60	No catch				
	NC 96	70	American shad	1	.01		
	US 70 Smithfield	115	American shad	2	.02		
			Hickory shad	2	.02		

Table 2. - (continued)

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Neuse River (Mainstem)	US 70A Smithfield	45	American shad	1	.02		
	SR 1908	60	No catch				
	NC 42	45	No catch				
	SR 1708	90	Herring			1	.01
	SR 2509	60	Hickory shad	3	.05		
	SR 2555	60	No catch				
	SR 1007	30	No catch				
	US 64	45	No catch				
Swift Creek	Above SR 1440 bridge	20	No catch				
	SR 1482	75	Herring	1	.01		
	SR 1440	120	Herring American shad	40 1	.33 .01	1	.01
	SR 1478	50	No catch				
	NC 118	105	No catch				
	NC 102	15	No catch				
Little Swift Creek	US 17	60	No catch				
	SR 1627	45	Herring	1	.02		
	SR 1624	15	No catch				
Batchelor Creek	Mouth	20	Herring			2	.10
	SR 1401	60	Herring	4	.07	27	.45
	NC 55	60	Herring	3	.05	1	.02

Table 2. - (continued)

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Batchelor Creek	US 70	90	Herring	1	.01	2	.02
	SR 1224	15	No catch				
Pinetree Creek	Mouth	55	Herring	5	.09	4	.07
Taylor Creek	Mouth	35	Herring	16	.46		
			Hickory shad	3	.09		
Turkey Quarter Creek	Mouth	94	Herring	8	.09	2	.02
	NW fork	25	Herring			18	.72
			Hickory shad			1	.04
	SW fork	24	Herring	2	.08	9	.38
			Hickory shad	1	.04		
Pitchkettle Creek	Mouth	74	Herring	160	2.16	21	.28
			Hickory shad	1	.01		
	Back	15	Herring			7	.47
Cove Creek	Mouth	15	No catch				
	NC 55	120	No catch				
	SR 1245	30	No catch				
Kitten Creek	Mouth	10	Herring			118	11.8
Village Creek	Mouth	5	Herring			58	11.6
Halfmoon Creek	Mouth	5	Herring			148	29.6
			Hickory shad			3	.6

Table 2. - (continued)

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Grindle Creek	Mouth	15	No catch				
	Back	12	No catch				
Contentnea Creek	NC 118	120	No catch				
	NC 11	15	No catch				
	SR 1004	60	Herring	3	.05		
	NC 123	60	No catch				
	US 13	105	Herring			1	.01
	SR 1222	30	American shad	1	.03		
	SR 1225	60	American shad	1	.02		
			Hickory shad	1	.02		
Little Contentnea Creek	NC 102	120	No catch				
	SR 1125	45	No catch				
	US 13	45	No catch				
	SR 1139	30	No catch				
Jericho Run Creek	SR 1809	75	No catch				
	NC 11	30	No catch				
Southwest Creek	SR 1804	45	No catch				
Falling Creek	SR 1340	75	No catch				
	US 70	15	No catch				
Bear Creek	SR 1311	15	No catch				
Walnut Creek	SR 1730	15	No catch				

Table 2. - (continued)

Area	Sample Site	Total sample Time(min)	Species	Eggs N	Eggs Eggs/min	Larvae N	Larvae Larvae/min
Little River	NC 581	75	Herring	1	.01		
			American shad	1	.01	5	.07
	US 70	15	No catch				
	SR 1234	110	American shad	1	.01		
	NC 42	15	Hickory shad	3	.2		
Beaverdam Creek	Mouth	15	No catch				
Mill Creek	Mouth	15	No catch				
	SR 1200	235	Hickory shad	1	.01		
			Herring	2	.01		
	SR 1009	105	American shad	3	.03		
	SR 1185	30	No catch				
Black Creek	I-95	15	No catch				
Middle Creek	NC 210	60	Herring	4	.07		
Swift Creek	NC 210	40	No catch				
Total		8,683		1,518		457	

Table 3. Observations of running ripe females and spawning activity by anadromous fish in the Neuse River, 1977-1979.

Location	Date	Species
Dawsons Creek	3/18/77	Alewife
	3/30/77	Alewife
	3/31/77	Alewife
	4/01/77	Alewife
Hancock Creek	4/07/77	Blueback herring
Slocum Creek	3/18/77	Blueback herring
	4/15/77	Blueback herring
Beards Creek	3/30/77	Blueback herring
	3/31/77	Blueback herring
	4/01/77	Blueback herring
Brices Creek	3/18/77	Blueback herring
	3/31/77	Blueback herring
	4/01/77	Blueback herring
	4/07/77	Blueback herring
	4/08/77	Blueback herring
	4/10/77	Blueback herring
	4/20/77	Blueback herring
	4/21/77	Blueback herring
Batchelor Creek	4/11/78	Blueback herring
Taylor Creek	4/05/78	Blueback herring
Pitchkettle Creek	4/04/77	Hickory shad
	4/07/78	Blueback herring
	4/11/78	Blueback herring
	3/30/79	Hickory shad
Swift Creek	4/05/78	Blueback herring
	4/25/78	Blueback herring
Little Swift Creek	4/07/78	Blueback herring
Village Creek	4/01/78	Blueback Herring
Contentnea Creek	4/06/78	Alewife
	4/11/78	Blueback herring
Neuse River Quaker Neck Dam	3/30/78	American shad

Utilization of such areas agrees with similar data for Albemarle Sound (Street et al. 1975) and the Tar-Pamlico River (Marshall 1976). Collections of river herring eggs and larvae indicated distribution and spawning areas extending beyond those recorded by Baker (1968) (Figure 7). River herring larvae were collected as far upstream as the SR 1708 bridge (Figure 6), approximately 70 river miles above the upstream range reported by Baker (1968). Cropland alterations on Slocum and Adams Creeks and South River have reduced habitat areas for river herring in the lower Neuse River (Baker 1968). In the middle and upper Neuse, channelization projects have eliminated spawning areas above the NC 118 bridge on Swift Creek, and on the entire Bear Creek area (Baker 1968). The Bear Creek channelization destroyed approximately five miles of previous river herring habitat. The channelization projects altered dark slow-flowing tributaries into shallow, swift flowing, sandy bottom streams unfavorable for anadromous fish habitation.

Some of the more important spawning areas delineated were Slocum, Smith, Dawson, and Upper Broad Creeks in the lower Neuse River, Swift, Pitchkettle, Taylor, and Turkey Quarter Creeks in the middle Neuse, and Mill Creek in the upper Neuse. River herring eggs were collected consistently from the SR 1740 bridge above New Bern to the SR 1915 bridge just below Goldsboro (from river mile 42 to river mile 128). Heavy rains in the spring produced considerable flooding that expanded river herring spawning areas into flooded low-lying swamps adjacent to the river during 1977 and 1978.

River herring eggs were found in many of the other Neuse River's tributaries: Beards, Hancock, Kershaw, and Trent Creeks in the lower Neuse; Jumping, Brice, Mill, and Mill Run Creeks in the Trent River; Little Swift, Batchelor, Pinetree, Village, Kitten, Halfmoon and Contentnea Creeks in the middle Neuse, and Little River and Middle Creek in the upper Neuse River. Running-ripe female alewife and blueback herring were first taken on 18 March in the lower Neuse River and were captured throughout the spawning period in several Neuse River tributaries (Table 3). Water temperatures ranged from 13^{o} - 26^{o}C. In 1977 and 1978 increases in river herring egg catch could be correlated with water temperature increases (Figure 8). Two spawning peaks could be seen in 1977, accompanied by parallel increases in water temperature. A similar peak could also be seen in the river herring egg capture in 1978. River herring larvae catch also corresponded somewhat with water temperature increases. Larval numbers were too low to consider during 1977 and 1979, and egg numbers too low in 1979.

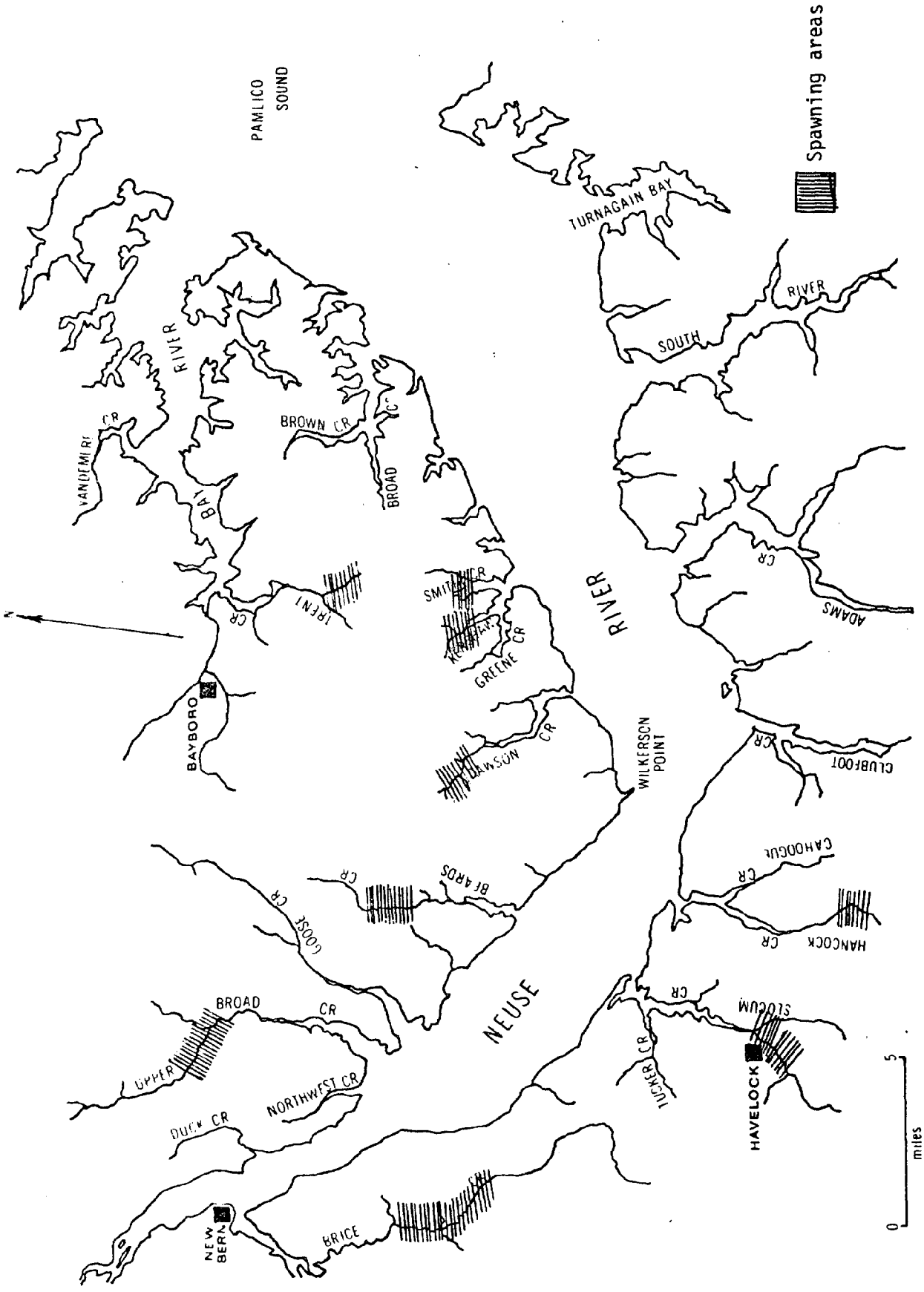

Figure 7 - River herring spawning areas in the Neuse River

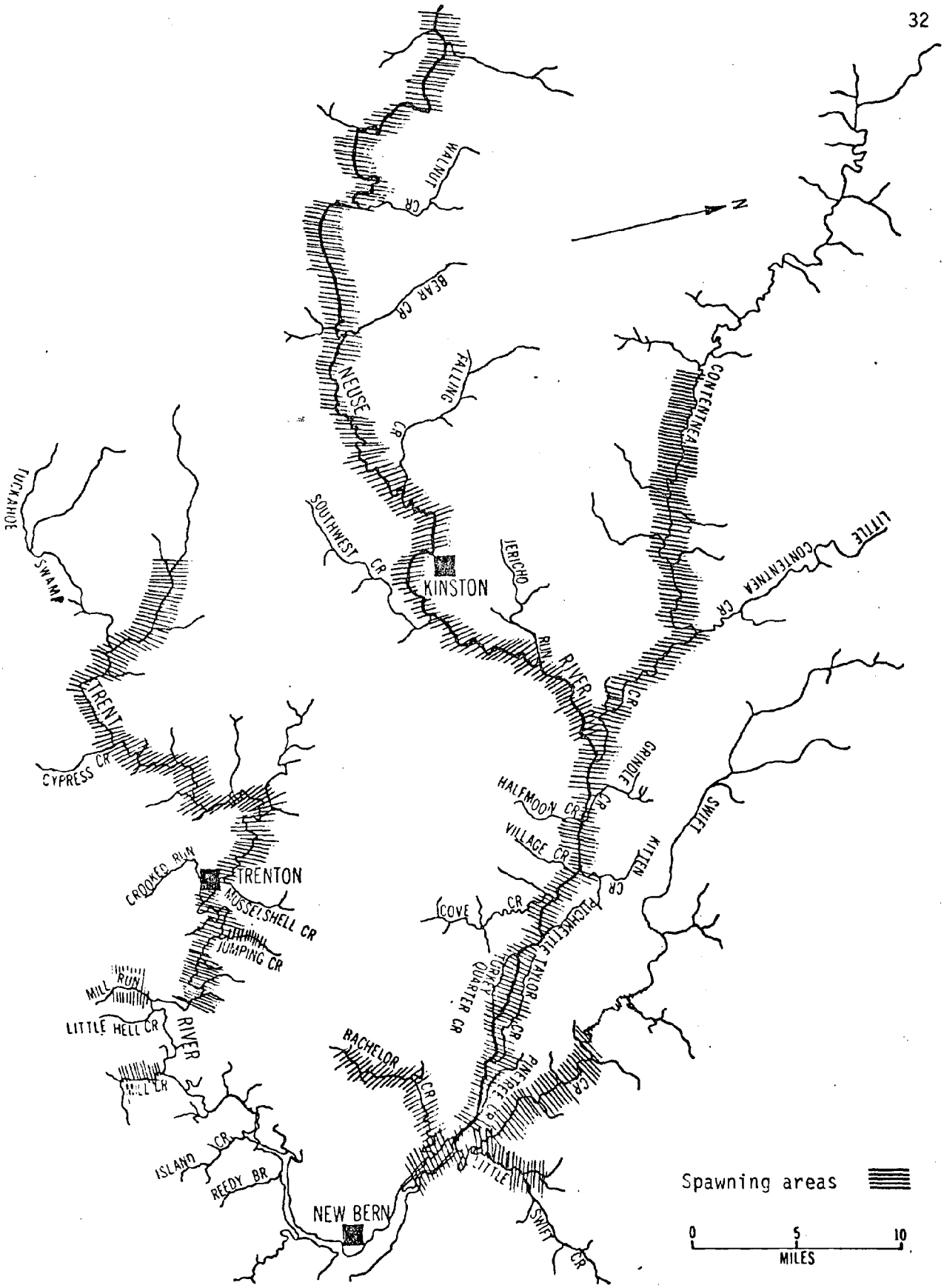

Figure 7 - continued.

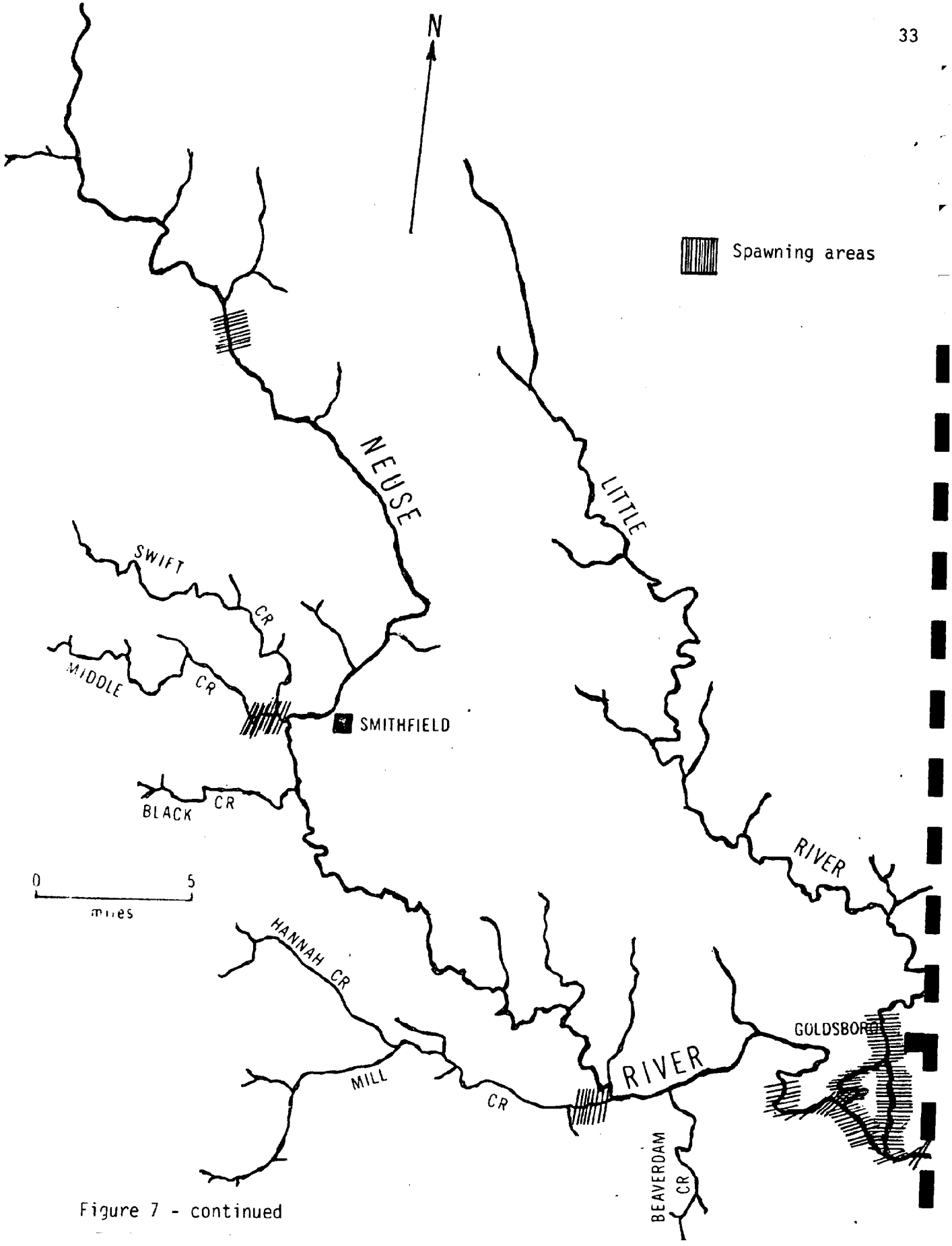

Figure 7 - continued

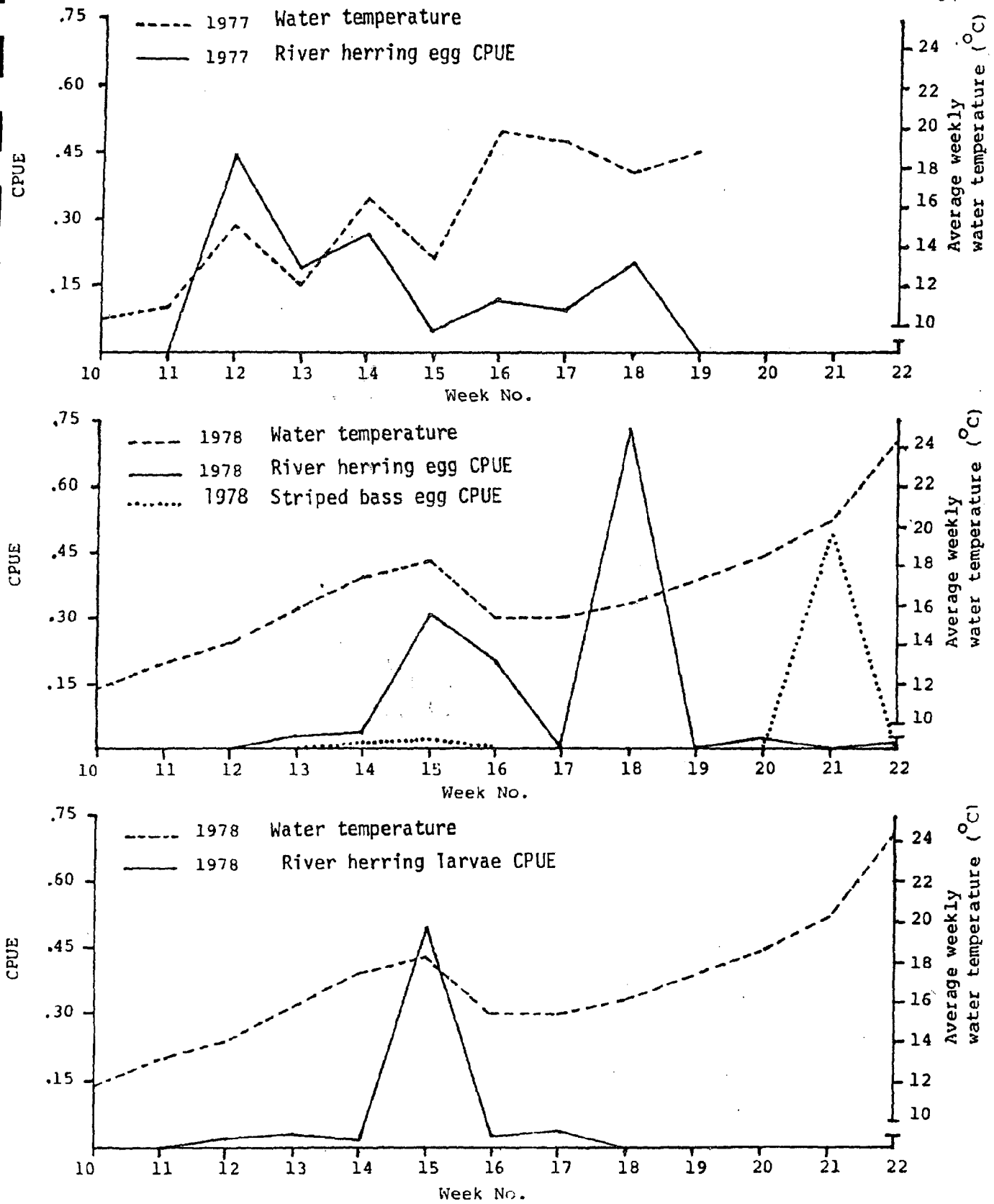

Figure 8 - Catch per unit effort for river herring eggs and larvae and striped bass eggs in relation to water temperature and week in the Neuse River, 1977-1978.

River herring larvae were captured in Mill Run of the Trent River, Trent River, Slocum Creek, Halfmoon Creek, Kitten Creek, Taylor Creek, Pitchkettle Creek, and Little River. Larvae were also collected in the main stem of the Neuse from the SR 1400 bridge (river mile 44) to the SR 1008 bridge (river mile 140) in Goldsboro, and at the SR 1700 bridge (river mile 200)in the upper Neuse.

The exact location of alewife spawning areas could not be accurately determined due to the difficulty in separating blueback herring eggs and larvae from those of alewife. As mentioned earlier, gill net sampling indicated that alewife were found primarily in the lower Neuse River; however, one running-ripe female was captured in Contentnea Creek and seven male alewife were caught in Beaverdam Creek. These catches indicate that alewife do utilize the upper Neuse River area.

American shad

American shad spawned from 31 March - 25 May in the Neuse River during 1977-79. Water temperatures for the spawning period ranged from 11^{o} - 26^{o}C, dissolved oxygen levels, 4-12 ppm, and pH concentrations, 6.4 - 8.0. The major spawning areas for American shad were located in the main stem of the Neuse River from just above New Bern to Smithfield, an area characterized by relatively swift currents (Figure 9). This characteristic supports the observation of Sholar (1976) that American shad eggs require sufficient current to remain suspended in the water column. Chittenden (1976) also found that the major shad spawning grounds of the Delaware River were located in the main river stem. However, a few American shad eggs were found in the Neuse River's larger tributaries: Trent River, Contentnea Creek, Swift Creek, Little River, and Mill Creek. Most of these tributaries are typified by dark and deep water with relatively slow currents that increase substantially during periods of heavy rainfall.

Baker (1968) reported that American shad ascended the Neuse much farther than found in this study. He stated that the range of shad extended to the Milburnie Dam at Raleigh, while in this project American shad were found only as far upstream as Smithfield, a difference of approximately 30 mi (48.5 km). Also, no American shad were found in Swift and Middle Creeks, two major upper Neuse River habitats reported by Baker (1968) to support shad. The primary tributaries utilized by American shad in the upper Neuse were Little River and Mill Creek. Walburg and Nichols (1967) stated that American shad spawning grounds in the Neuse River extended from New Bern to the low-head dam at Goldsboro; however, shad eggs were found as far upstream as Smithfield.

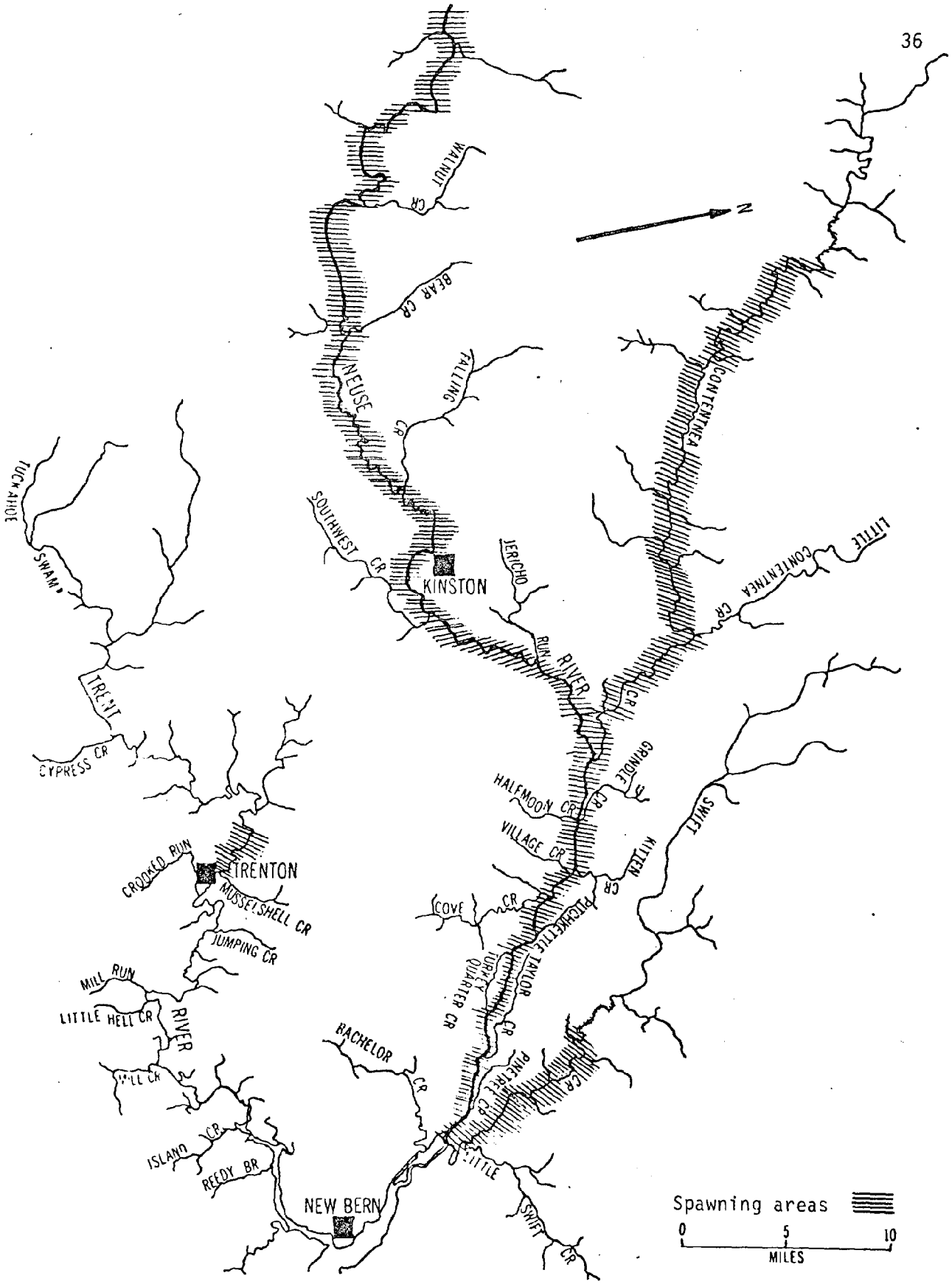

Figure 9 - American shad spawning areas in the Neuse River.

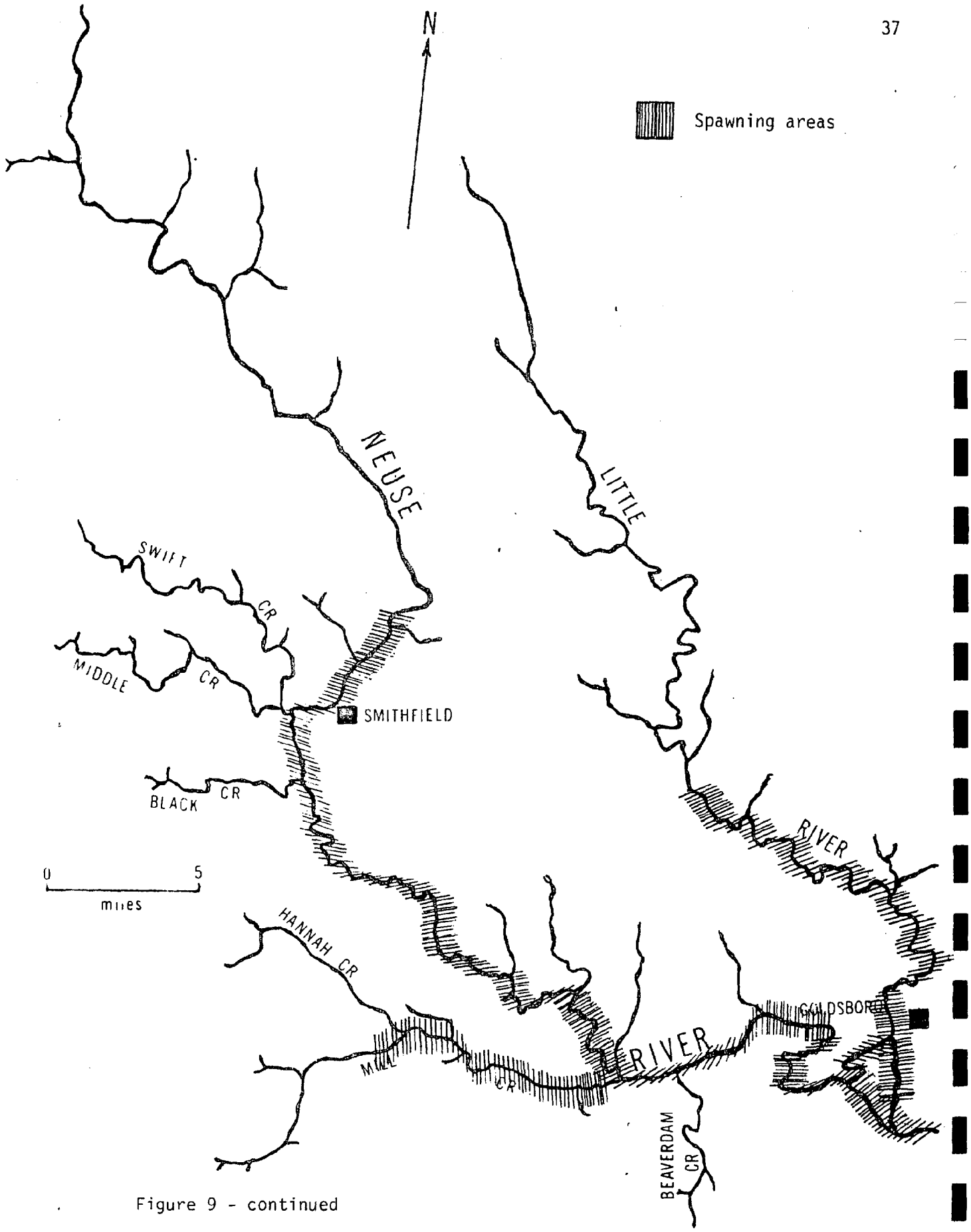

Figure 9 - continued

American shad egg catches were relatively scarce in the Neuse River; the highest catch was six from the SR 1731 bridge near Seven Springs. The low egg catch made estimation of a spawning peak impossible. American shad larvae were found from Kinston (river mile 85) to the SR 1224 bridge above Goldsboro (river mile 145). Larval catches were also rare; the largest number being five which came from Little River (NC 581 bridge). One running-ripe American shad was captured in the Neuse River on 4 April 1978 near the low-head dam at Goldsboro, at a water temperature of 19°C.

Hickory shad

Egg sampling in the Neuse River during 1977-79 yielded only 23 eggs and four identifiable hickory shad larvae. Based on these collections, hickory shad spawning areas have been tentatively located (Figure 10). Eggs were found in the middle Neuse River from the NC 55 bridge (river mile 80) to the SR 1731 bridge (river mile 97), in the upper Neuse River from Smithfield (river mile 80) to the SR 2509 bridge (river mile 210), and in several tributaries. The tributaries where hickory shad eggs or larvae were captured were Turkey Quarter, Pitchkettle, Taylor, Halfmoon, Contentnea, and Mill Creeks, along with Little and Trent Rivers. Pate (1972) also found that hickory shad utilized Pitchkettle and Taylor Creeks as spawning grounds. Hickory shad, much like herring, seemed to prefer the slow-flowing, deep, and dark-water tributaries as spawning areas. Baker (1968) also noted that hickory shad often inhabit the smaller tributaries of the Neuse River.

Hickory shad spawning occurred from 27 March to 4 May, at temperatures of 13°-18.5°C for the three year study period. Temperatures and spawning duration were very similar to those reported by Pate (1972). Eggs were caught at a pH range of 6.4 - 6.6, and at dissolved oxygen levels of 5 - 10 ppm. Catches were insufficient to determine spawning peaks. Hickory shad larvae were captured only in Halfmoon and Turkey Quarter Creeks. Running ripe females were observed in late March and early April in Pitchkettle Creek during 1977-78, at water temperatures of 18°C and 19°C (Table 3).

Striped bass

Striped bass eggs were captured only during the second segment of the project, when investigations concentrated on the area between New Bern and Goldsboro. Eggs were collected from the NC 55 bridge at Kinston (river mile 80) to the SR 1224 bridge above Goldsboro (river mile 145) (Figure 11). Striped bass spawned in the

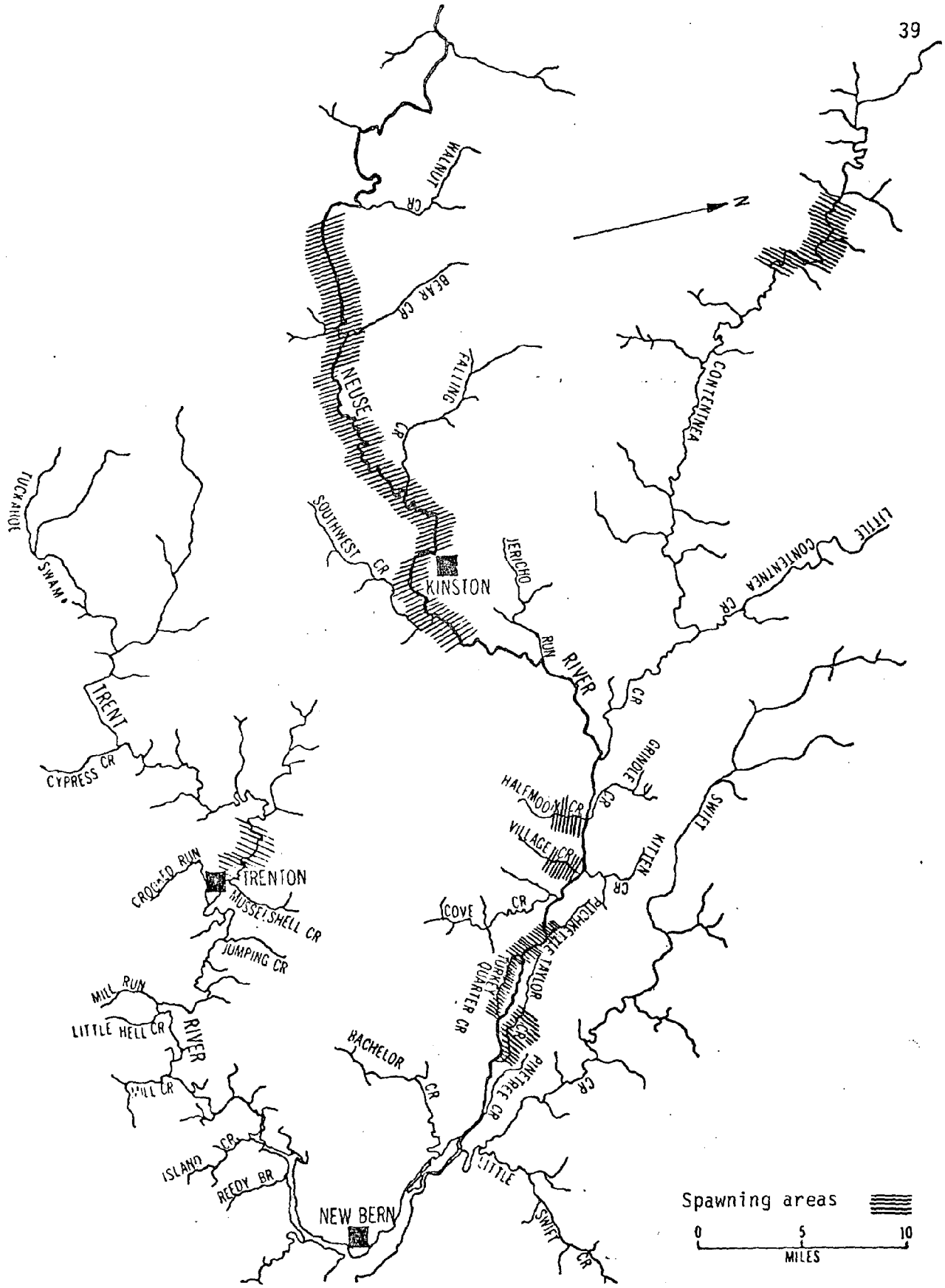

Figure 10 - Hickory shad spawning areas in the Neuse River.

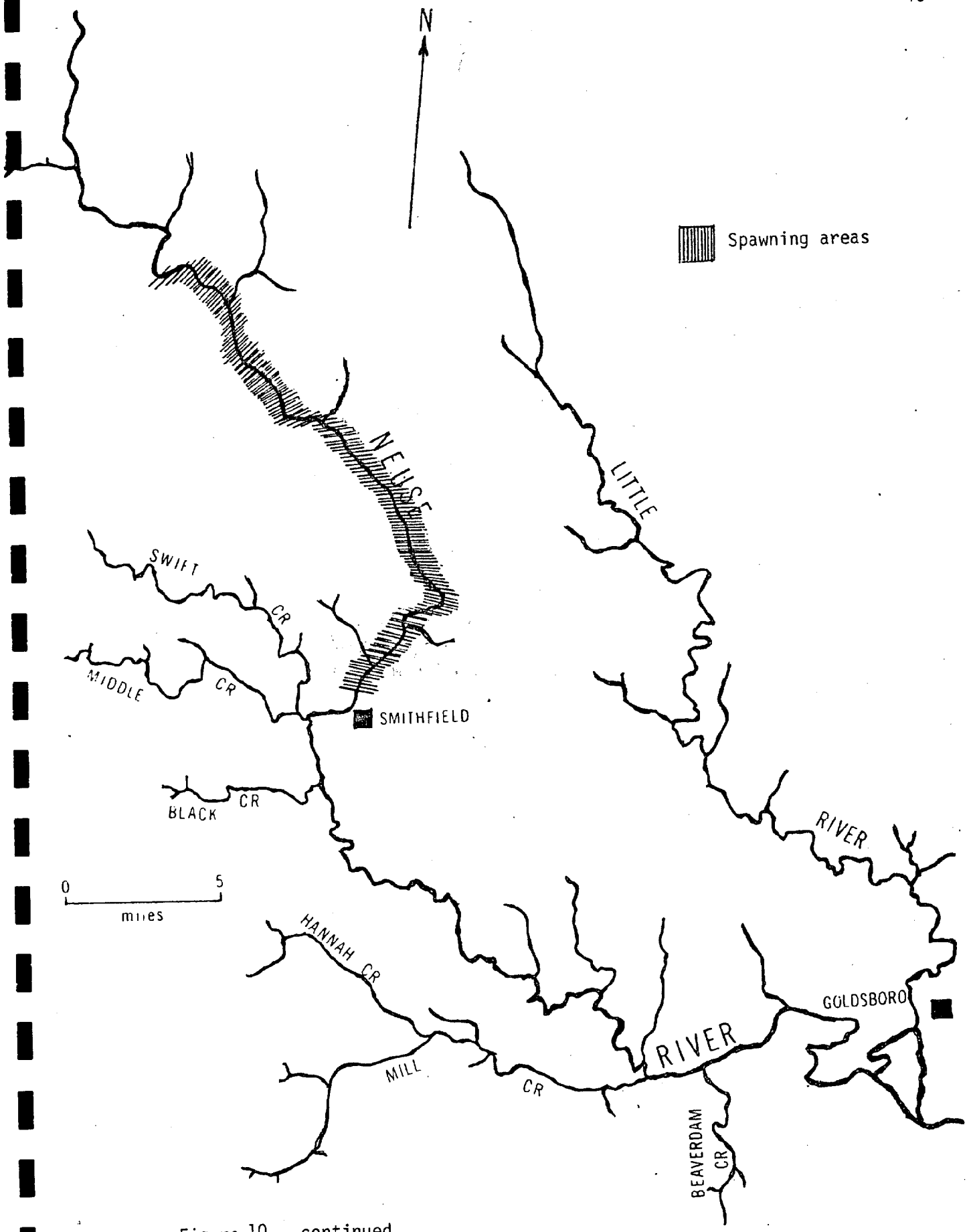

Figure 10- continued

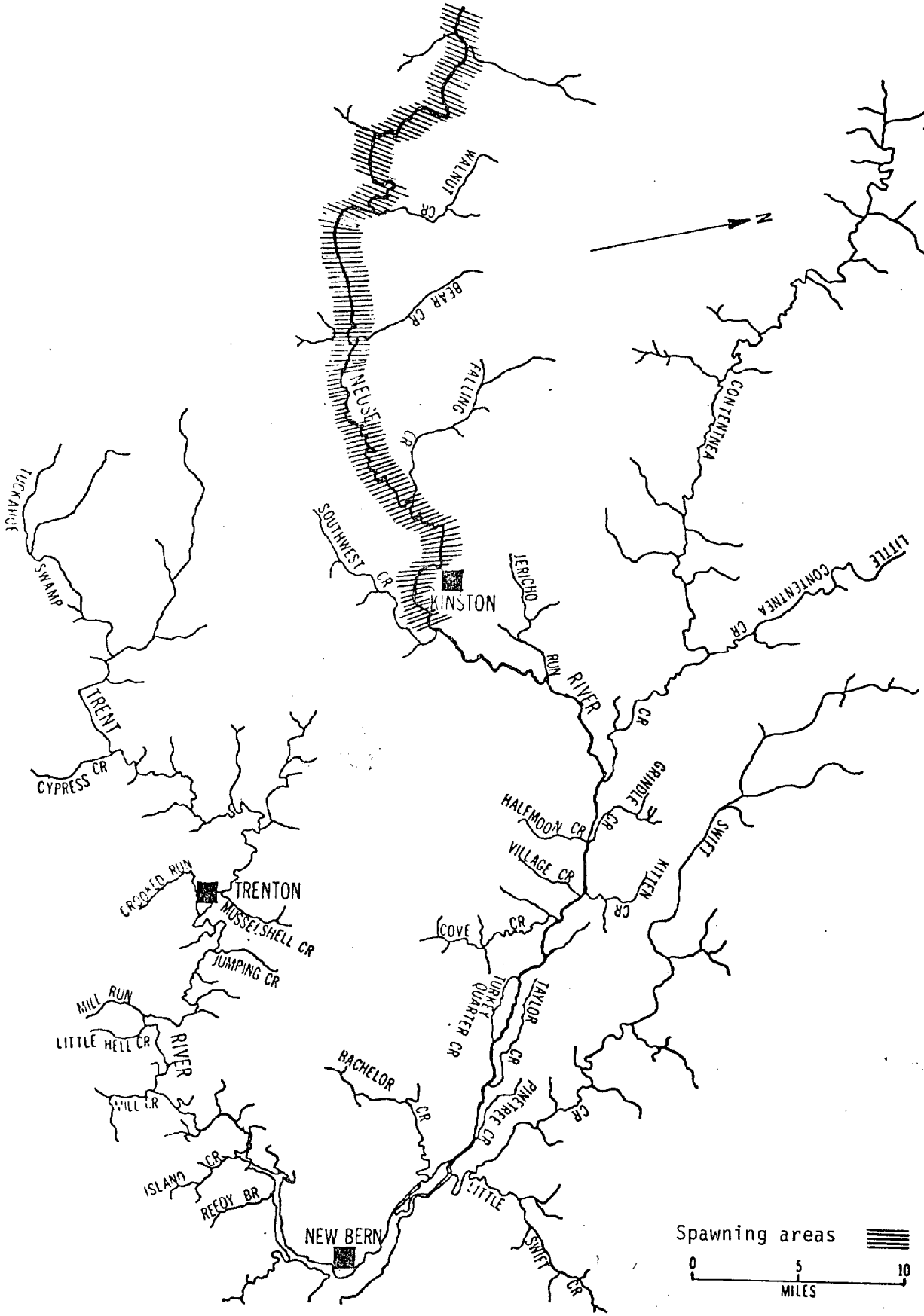

Figure 11- Striped bass spawning areas in the Neuse River.

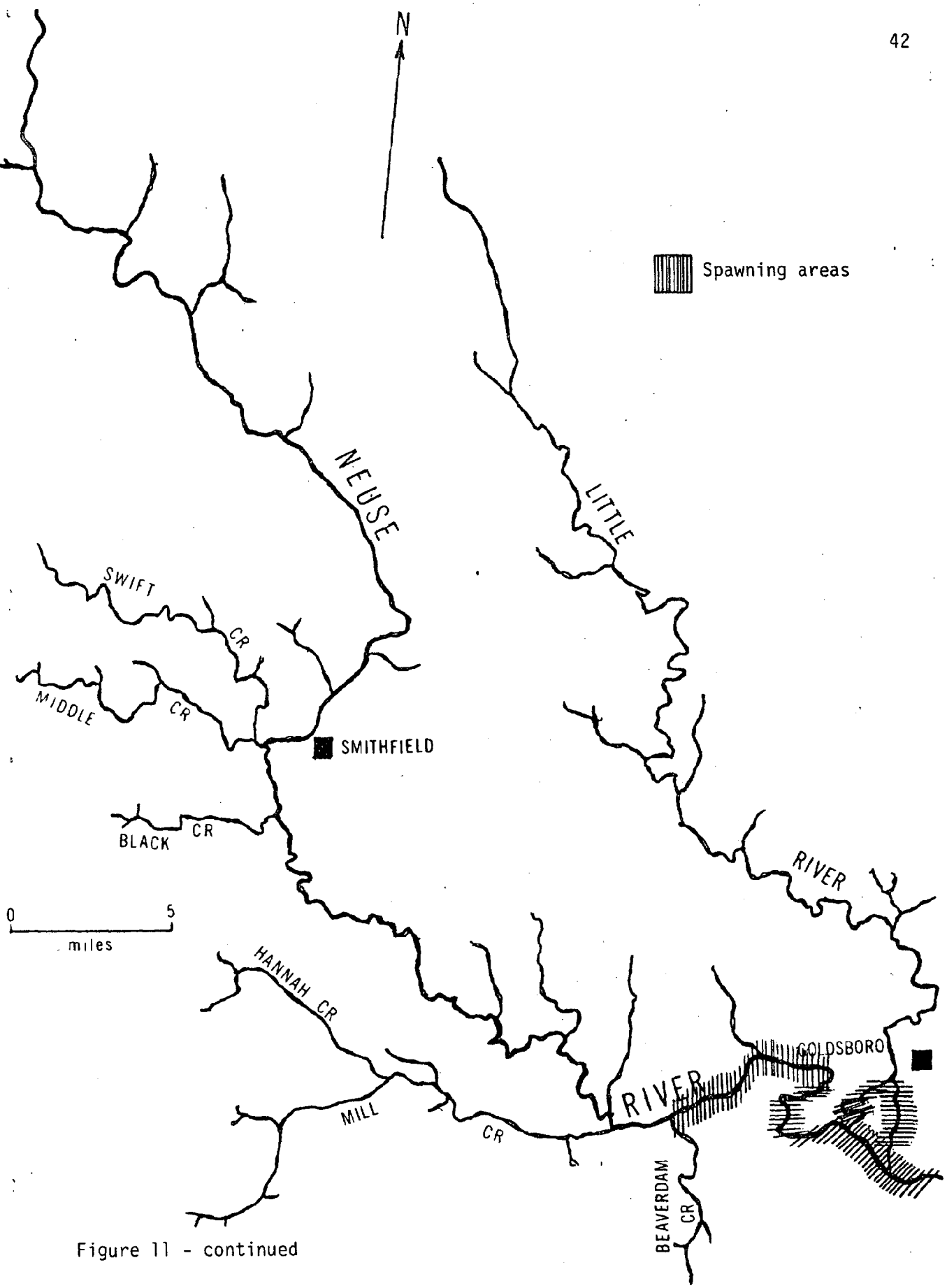

Figure 11 - continued

middle Neuse River from 27 March to 30 May at water temperatures of 13.5° - 24°C, pH concentrations of 6.4 - 6.9, and dissolved oxygen levels of 5 - 10 ppm. The spawning duration and temperatures were somewhat different from those recorded by Baker (1968) in the Neuse. He collected striped bass eggs from 3 April to 13 May at 19° - 21°C. Baker (1968) also stated that striped bass migration into inland waters is stopped by the Quaker Neck dam at Goldsboro. During this study, one striped bass egg was discovered above Goldsboro, indicating that while striped bass habitat does extend above the low-head dam, distribution is probably greatly hindered by the dam.

The principal striped bass spawning area in the Neuse River lies between the NC 55 bridge (river mile 80) and the SR 1915 bridge (river mile 120). This is the only area in the Neuse River where striped bass eggs were consistently caught. Evidently, that section of the river is turbulent enough to prevent the striped bass eggs from settling to the bottom where they could be silted over. Bigelow and Schroeder (1953) stated that such a current is a principal requirement for successful spawning of striped bass.

Although striped bass egg catches were relatively low, two spawning peaks could be detected that possibly correlated with increases in water temperature (Figure 8). High numbers of striped bass eggs (.14 eggs/min) were collected during week 15 (9-15 April), when water temperatures rose to an average of 21.5°C. Relatively large numbers (.17 eggs/min) continued to be caught until water temperatures dropped to an average of 18°C during week 16. Low water temperatures were correlated with a lack of egg catches until week 21 (21-27 May), when the water temperature rose to 20°C, and the egg catch peaked at .49 eggs/min. No eggs were taken after week 21. One striped bass larvae was caught near the SR 1151 bridge in 1978.

Estimates of striped bass spawning in 1978 relative to 1977 and 1979 seem to indicate a successful spawning year. The combination of strong currents produced by heavy spring rains and optimum water temperature during weeks 15, 16, and 21 probably contributed significantly to the successful striped bass spawn in 1978.

Juvenile Sampling

During January - December, 1976-79, a total of 11,711 juvenile anadromous fishes were captured in the Neuse River. The most abundant juvenile anadromous fish caught was blueback herring (10,011), far surpassing American shad (716),

alewife (58), hickory shad (916), and striped bass (10). Anadromous juveniles were caught with wing trawls, flat trawls, seines, and other experimental gears. The beach seine and surface wing trawl were more effective in capturing anadromous fish than the flat trawl. The overal CPUE in the Neuse River for the wing trawl during June-October, 1976-79 was 2.45,while that for the seine was 9.0. The CPUE values were compared to an overall CPUE of only .77 for the flat trawl (Table 4). The difference is probably due to the apparent tendency of alosids, especially blueback herring, to inhabit shallow or surface and mid-water areas. Street, et al. (1975) and Johnson, et al. (1977) inferred that blueback herring preferred shallow water areas for nursery grounds. Burbidge (1974) also found that juvenile blueback herring were concentrated in surface waters in the James River, Virginia. Significantly more American shad were also caught with the wing trawl and seine than with the flat trawl, with 16.2% of the total shad being caught in the wing trawl and 83.6% with the seine. Less than 1% of the juveniles were captured with the flat trawl. It should be noted that most of the samples taken with the flat trawl were made downstream from the principal anadromous fish nursery area (Figure 4).

Blueback herring

Nursery Area - Sufficient numbers of blueback herring were captured to permit general delineation of nursery areas and provide a picture of growth, movement, and relative abundance. Catches of juvenile blueback herring were highest in the Neuse and Trent River upstream from New Bern. In the Neuse River, relatively large numbers (30% of the four year total) were found consistently in the Swift Creek area. Three percent of the total blueback herring catch came from Turkey Quarter Creek. The principal area consistently utilized by juvenile blueback herring was from Flower's Gap to Cove Creek, an area covering approximately 15 miles (Figure 12).

The downstream limit of the blueback herring nursery area in the Neuse River is at the transition of the river from a slow-moving, swamp-bordered stream to a marsh-bordered estuary subject to salt water intrusion. This alignment is similar to that found by Marshall (1976) in the Tar-Pamlico River system. Relatively deep, slow-flowing, black waters that drain hardwood swamps, characterize the apparent nursery areas for blueback herring in the Neuse River.

Movement - Juvenile blueback herring were generally distributed throughout the Neuse River after spawning, inhabiting tributaries or moving into the main stem of the river. Juveniles were collected from upper Broad Creek region near New Bern

Table 4. - Catch and catch-per-effort of juvenile anadromous fishes, by gear, from the Neuse River, NC, June-October, 1976-1979

	Wing Trawl					1/4" Flat Trawl					Seine				
YEAR	1976	1977	1978	1979	1976-79	1976	1977	1978	1979	1976-79	1976	1977	1978	1979	1976-79
EFFORT	624	1225	525	340	2714	0	0	21	50	21	14	33	56	39	142
Blueback herring															
Catch	169	2935	3282	149	6535	0	0	52	0	52	0	3	675	64	742
CPUE	.27	2.4	6.25	.44	2.41	0.0	0.0	2.5	0.0	.73	0.0	.09	12.05	1.6	5.2
Percent	100	99.0	82.0	70.0	89.2	0	0	.01	0.0	.7	0	.1	17.0	30	10.1
Alewife															
Catch	0	1	1	0	2	0	0	2	0	2	0	0	6	0	6
CPUE	0.0	.01	.01	0.0	>.1	0.0	0.0	.09	0.0	.03	0.0	0.0	.11	0.0	.04
Percent	0	100	.11	0	20.0	0	0	.22	0	20	0	0	.66	0	60
American shad															
Catch	19	23	66	8	116	0	0	1	0	1	0	479	105	14	528
CPUE	.03	.02	.13	.02	.043	0.0	0.0	.05	0.0	.01	0.0	15.0	1.9	.36	3.7
Percent	100	.05	.38	.36	16.2	0	0	.006	0	.1	0	.95	.61	.64	83.6
Hickory shad															
Catch	0	4	1	0	5	0	0	0	0	0	0	0	3	0	3
CPUE	0.0	.01	.01	0.0	>.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.05	0.0	>.1
Percent	0	100	.25	0	62.5	0	0	0	0	0	0	0	.75	0	37.5
Striped bass															
Catch	0	0	0	2	2	0	0	0	0	0	0	0	4	0	4
CPUE	0.0	0.0	0.0	.01	>.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.07	0.0	>.1
Percent	0	0	0	.33	33	0	0	0	0	0	0	0	.67	0	.67
TOTAL															
Catch					6660					55					1283
CPUE					2.45					.77					9.0
Percent					.83					1					16

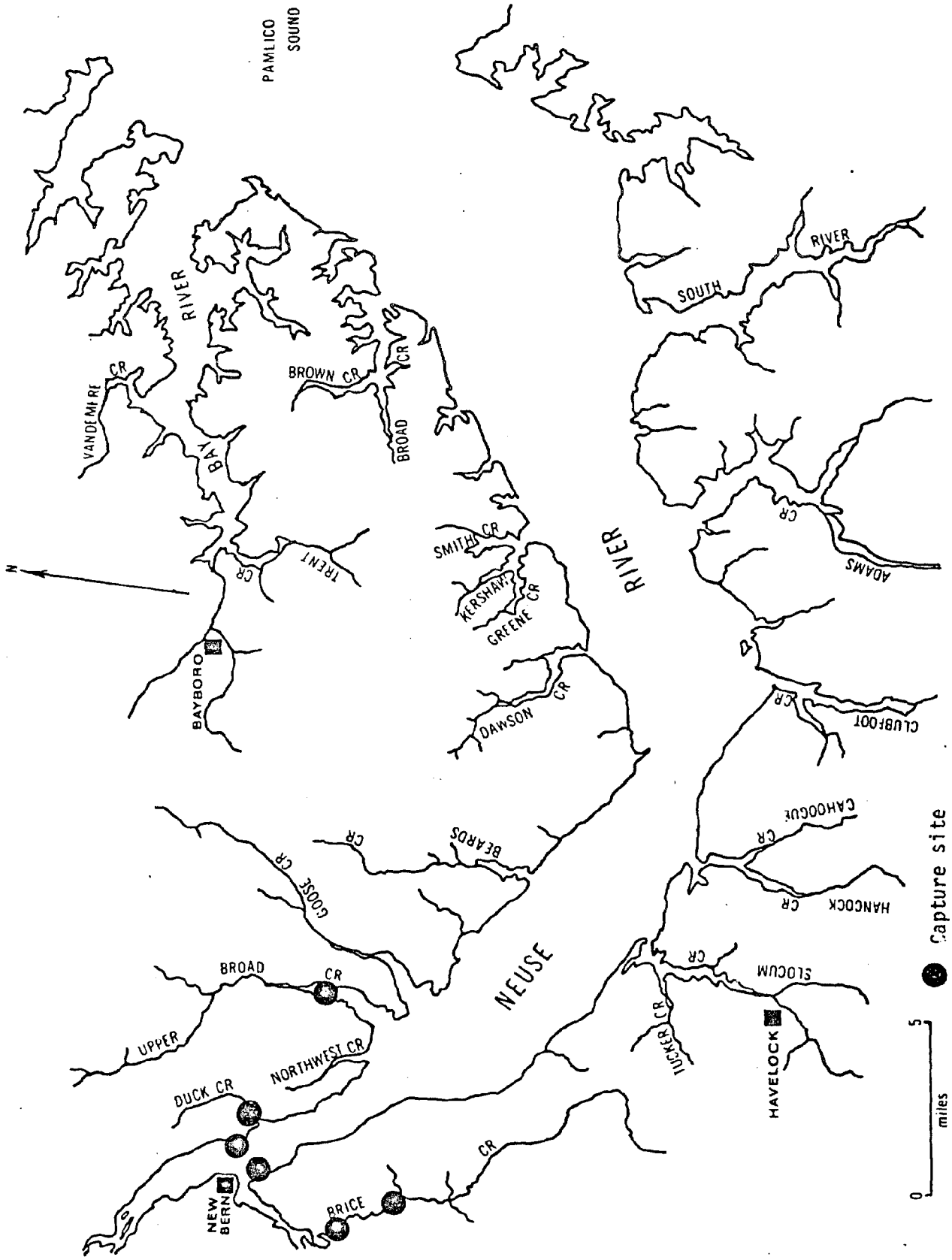

Figure 12. - Capture sites of juvenile blueback herring in the Neuse River, NC, 1977-1979.

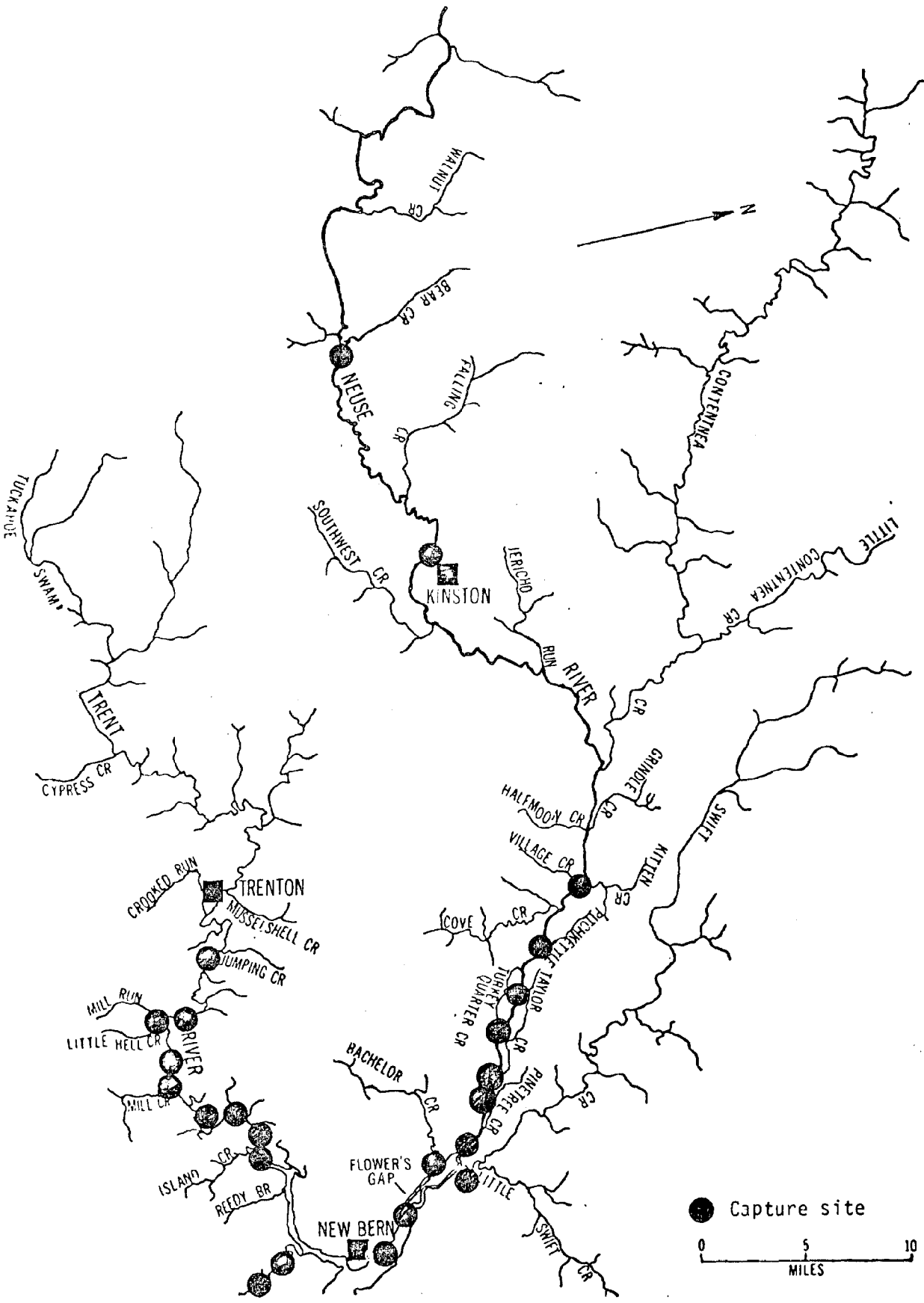

Figure 12 - continued.

t The SR 1152 bridge near Bear Creek from May through November. Blueback herring were captured in all areas of the Neuse; being found in tributaries, close to shorelines, and in the main stem of the river. This dispersal is similar to what Street, et al, (1975) found in Albemarle Sound for the months of May - June.

Street, et al. (1975) and Loesch (1968) stated that downstream migration of blueback herring to wintering areas took place with the onset of cold weather. However, movement of juvenile blueback herring into estuarine waters could not be detected in the Neuse River through 1977-79. Numerous factors could have influenced this apparent lack of migration; the Fall seasons of 1977-79 were unusually warm, with water temperatures ranging from 15°C - 19°C even in November. Also possible juvenile movement in and out of the Neuse River tributaries complicates any determination of blueback migration. There was no indication of juvenile bluebacks moving out of the tributaries, as high densities of herring were found in Swift Creek from June - November, 1976-79, the only tributary located in the major nursery area which was sampled for juveniles. Catch-per-unit-effort values did decrease in the fall during 1977 and 1979, but showed a great increase in 1978 (Figure 13). A general movement of juvenile blueback herring into the lower section of the Neuse River during late fall and winter was documented by Spitsbergen and Wolff (1974). More than 99% of the juvenile bluebacks they caught were taken from December to March. This trend of movement into estuarine waters was also noted by Marshall (1976) in northern Pamlico Sound, and by Street, et al. (1975) in Croatan Sound. Spitsbergen and Wolff (1974) reported that juvenile blueback herring utilize the shallow muddy tributaries in the brackish water sections of the Neuse as secondary nursery areas. Total migration of bluebacks into Pamlico Sound evidently occurs as the spring spawning migration of adults begins.

Information on movement and behavior of blueback herring in nursery areas is very limited. Street, et al. (1975) suggested that migration from the nursery areas was size-related. However, Godwin and Adams (1969) believed that a size-migration relationahip did not apply to blueback herring in the Altamaha River, Georgia. Burbage (1974) stated that juvenile blueback herring movement in the James River, Virginia could be affected by migration into and out of tributaries, differing survival rates in the upstream and downstream sections of the river, food availability, and river current rates.

Growth - Separate growth curves for the 1976, 1977, 1978, and 1979 year classes of juvenile blueback herring have been plotted, in addition to a growth curve combining all year classes (Figure 14). Growth during 1977 and 1978 was similar,

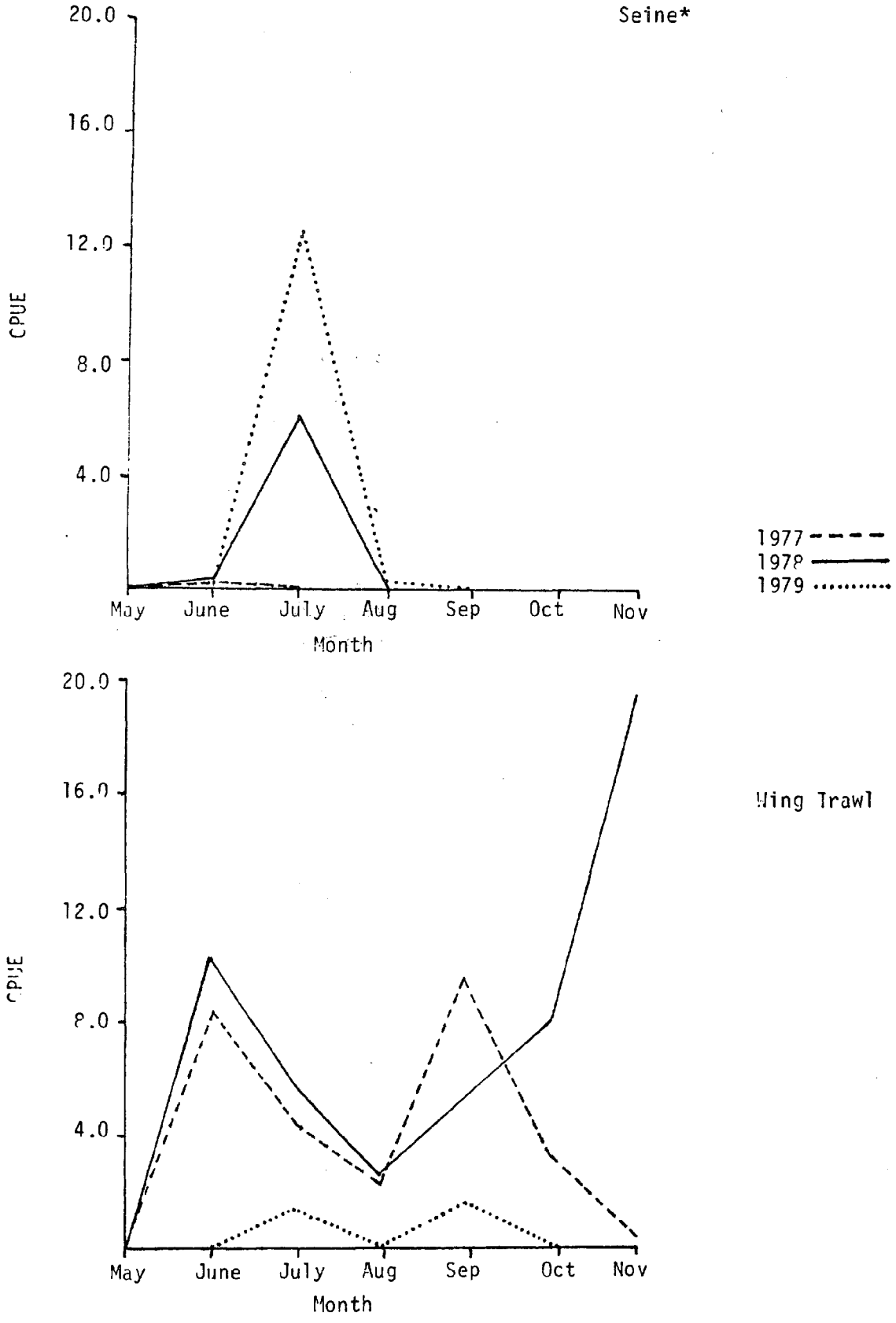

Figure 13 Monthly catch per effort of juvenile blueback herring, Neuse River, May-November, 1977-1979.
* Stations above New Bern were used for seine data

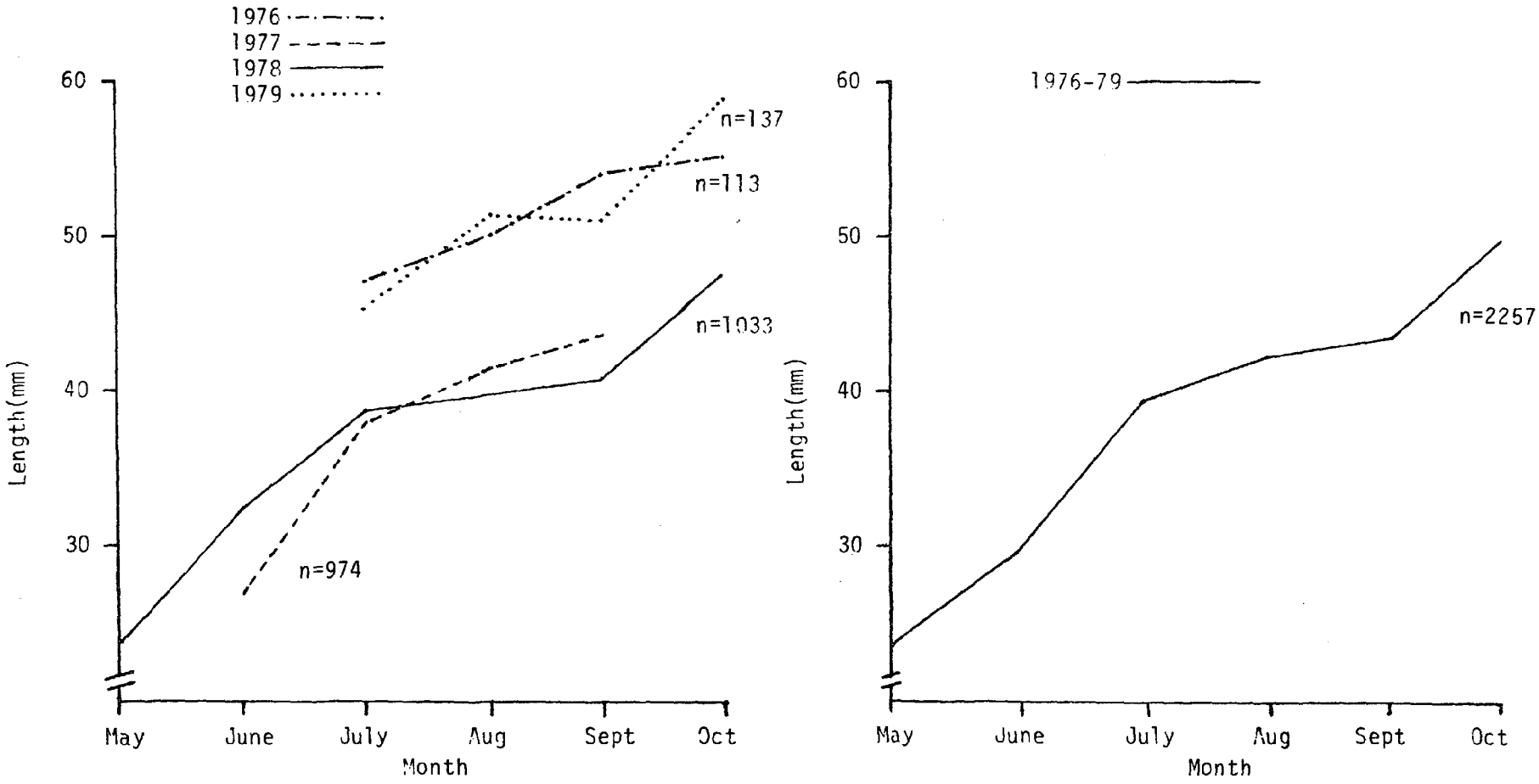

Figure 14 Mean fork length of blueback herring by month for the Meuse River, 1976-1979.

as was growth during 1976 and 1979. The higher apparent growth rates in 1976 and 1979 may have been due to the relatively small sample size, which probably was reflective of poorer year classes. The 1977 and 1978 Neuse River growth rates resemble those of blueback herring in Albemarle Sound, Northeast Cape Fear River, Cape Fear River and Tar-Pamlico River (1974-76) (Table 5). The general flatness of the growth curve during July-October may be related to juvenile movement, suggesting emigration of the larger fish, as Street, et al. (1975) and Johnson, et al. (1977) found for Albemarle Sound.

Juvenile monitoring in the Tar-Pamlico system consistently produced smaller blueback herring than those in the Neuse for 1977-79 - the average difference in length for the corresponding month between the two rivers was approximately 6 mm (Table 5). This factor could be related to numerous factors, such as food availability, feeding selectivity, differing growth efficiencies for the two systems, and length of stay in the nursery areas.

Relative abundance - Juvenile sampling with various trawls and seines was conducted according to standard procedures in order to compare results from different samples taken with the same gear. Such data should show relative changes in juvenile abundance among year classes. Table 6 exhibits relative abundance of the 1977-79 year classes of blueback herring for the Neuse River. Greater abundance was evident in 1977 and 1978 relative to 1979. The 1979 year class was apparently quite poor in the Neuse River.

Alewife

The small number (58) of juvenile alewife collected during the study prevented delineation of nursery areas in Neuse River. Of the total, 48 were caught during a supplemental sample near Beards Creek in July, 1977 (Figure 15). Alewife were also captured in and around the mouth of the Trent River and From Duck Creek. The juveniles ranged from a minimum of 35 mm in June to a maximum length of 82 mm in July. Most of the juveniles were caught during seine sampling at night. Low numbers of juvenile alewife in the Neuse River were also encountered by Spitsbergen and Wolff (1974).

Spitsbergen and Wolff (1974) reported juvenile alewife in many of the same areas as blueback herring during November through Marah in the lower Neuse River. Most of the alewife were caught during March and ranged in size from 55 to 95 mm.

Table 5. - Comparison of mean length (mm) of juvenile blueback herring by month from Neuse River and other North Carolina locations.

Location and Reference	June	July	Aug.	Sept.	Oct.
Northeast Cape Fear River [1]					
1975		39	44	45	47
1976	35	34	44	45	48
Cape Fear River[2]					
1977	31	47	51	58	65
1978	27	35	39	49	
Albemarle Sound[3]					
1972	31	41	44	47	49
1973	26	33	37	40	41
1974		41	44	40	49
1975		37	39	42	40
1976	28	35	48	49	
1977	28	35	35	41	42
1978	25	38	42	51	52
Tar-Pamlico River[4]					
1974	31	37	47	46	58
1975	27	34	42	43	48
1976	41	45	50		
1977	26	30	36	36	38
1978	29	34	39	38	39
1979	32		43		
Neuse River					
1976		47	50	54	55
1977	34	38	42	44	
1978	32	38	40	41	48
1979		45	52	50	59

[1]Sholar 1977

[2]Fischer 1979

[3]Data for 1972-73 from Street et al. (1975), for 1974-76 from Johnson et al. (1977), and for 1977-78 from Johnson et al and Loesch et al (1978).

[4]Data for 1974-76 from Marshall (1976)

Table 6. - Relative abundance of juvenile blueback herring captured by wing trawls in the Neuse River, NC, June-October, 1977-1979.

	Neuse River					
	1977		1978		1979	
	N	CPUE	N	CPUE	N	CPUE
June	871	8.29	1050	10.00	0*	0.0
July	431	4.10	596	5.67	110	1.05
August	207	1.97	259	2.46	3	.03
September	1,000	9.52	544	5.18	10	.10
October	332	3.16	833	7.93	0	0.0
Total	2,841	5.44	3282	5.21	123	.36

*No effort was expended

(Only similar 1977-1979 wing trawl stations are used. Trent River data are combined with Neuse River data)

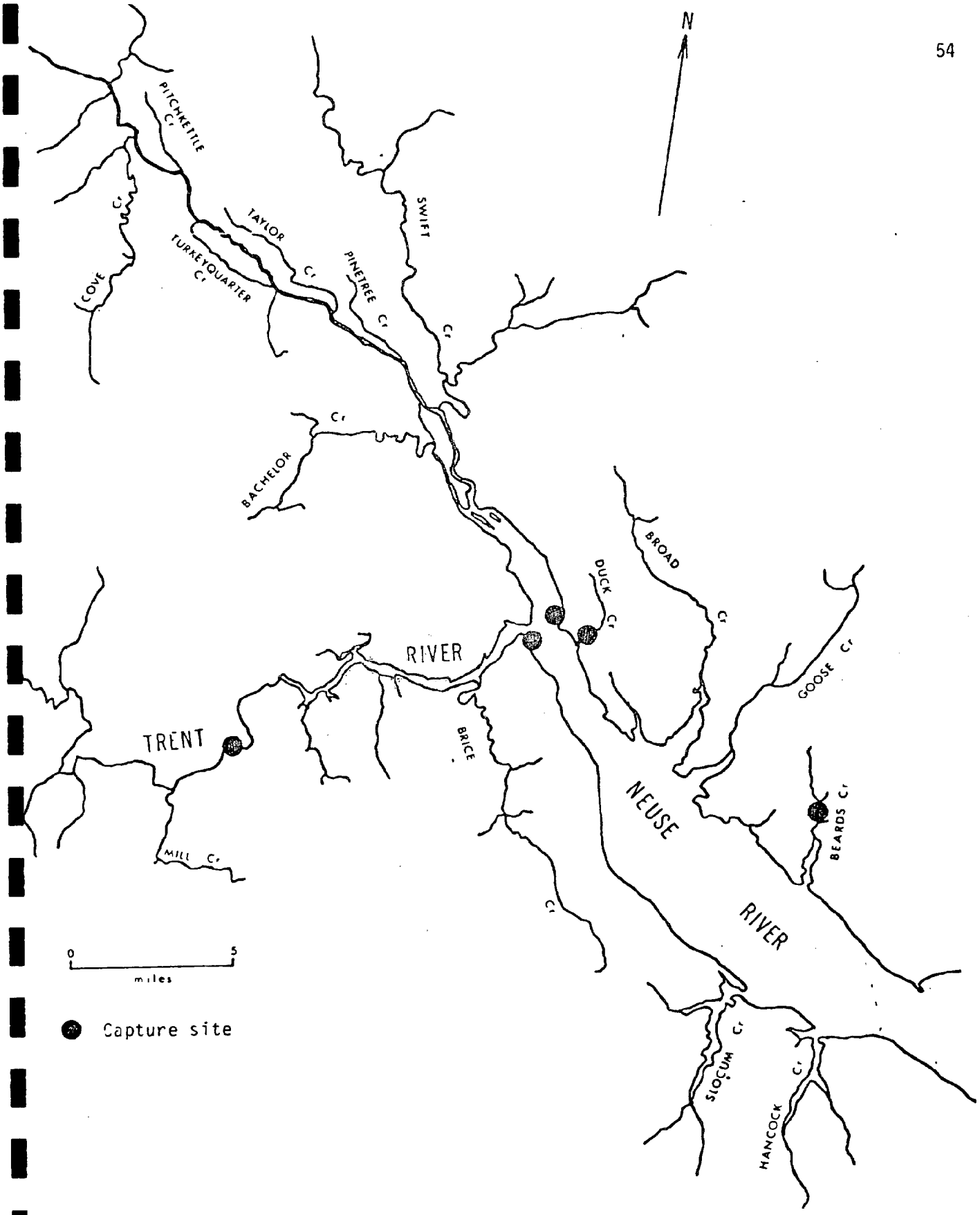

Figure 15 - Capture sites of juvenile alewife in the Neuse River, NC, 1977-79.

No definite observations on juvenile alewife growth and movement could be made due to the low numbers of juveniles encountered. The data collected on river herring during this project and by Spitsbergen and Wolff (1974) indicate that blueback herring are by far the major river herring utilizing the Neuse River. The low juvenile population of alewife compared to the relatively high numbers of bluebacks raises questions on habitat preference and may reflect the fact that the Neuse River is near the southern end of the geographic range for alewife (Bigelow and Schroeder 1953).

American shad

Nursery Area - Although relatively few juvenile American shad were collected (716), tentative nursery areas could be delineated in the Neuse River. As found with blueback herring, most American shad were captured in the Trent River and the Neuse River upstream from New Bern. A large majority of the juvenile shad were caught at the SR 1400 bridge near Pinetree Creek, where 475 were caught in June, 1977 during a single supplemental sample. Many juveniles were also caught at the SR 1224 bridge above Quaker Neck dam near Goldsboro, indicating that a significant amount of spawning may have occurred upstream from the dam. The general area utilized by juvenile American shad is from Duck Creek (river mile 35) to the SR 1224 bridge above Goldsboro (river mile 145), as shown in Figure 16.

Juvenile American shad were found in the Neuse River from June through November with most fish being taken in June and July at a size range of 31-53 mm. Spitsbergen and Wolff (1974) reported the capture of seven juvenile American shad in the lower Neuse River during March, when the fish were evidently utilizing the lower estuarine waters as wintering areas.

Movement - After spawning, juvenile American shad were found throughout the middle and upper Neuse River. The shad appeared more abundant over sand or gravel bottom, similar to that reported by Walburg and Nichols (1967). However, this apparent habitat preference might be due to gear and sampling site limitations. Water depth and obstructions limited trawl sampling to areas below the SR 1470 bridge. Upstream areas were sampled with beach seines, which were effective only on sandy bottoms or in areas with beaches suitable for landing the net. These limitations could have accounted for the apparent habitat preference of American shad for sandy bottoms.

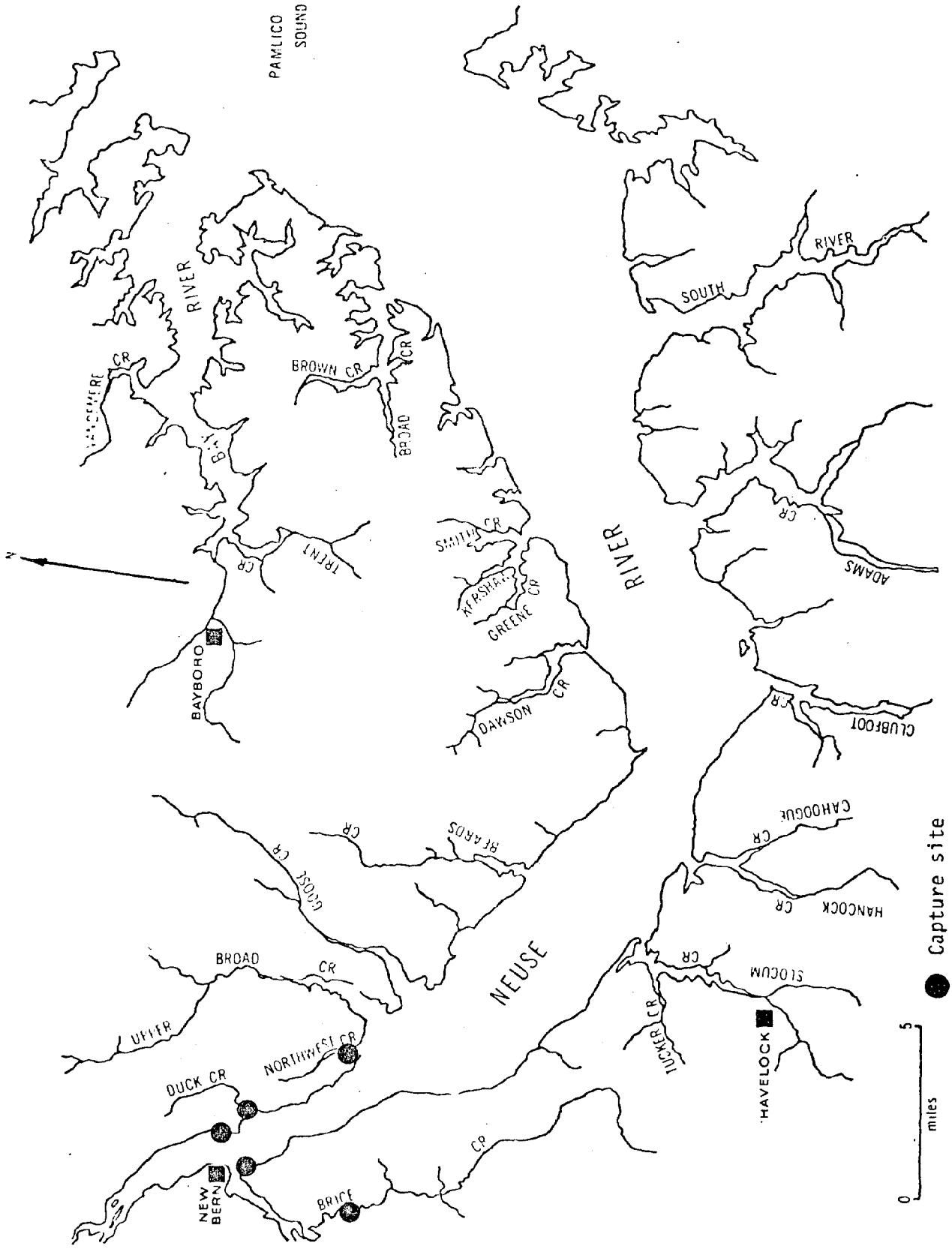

Figure 16. - Capture sites of juvenile American shad in the Neuse River, NC, 1977-1979.

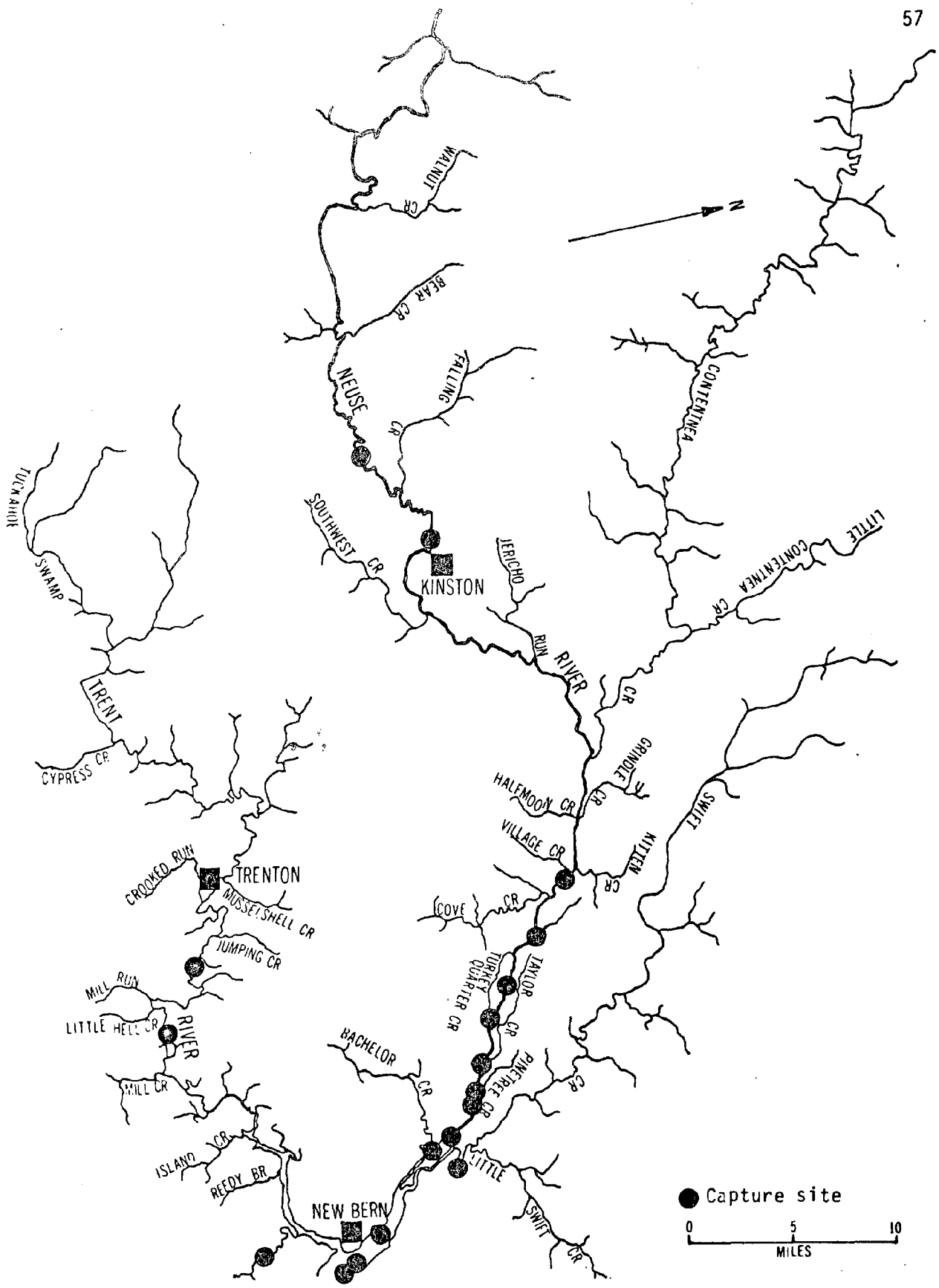

Figure 16. continued.

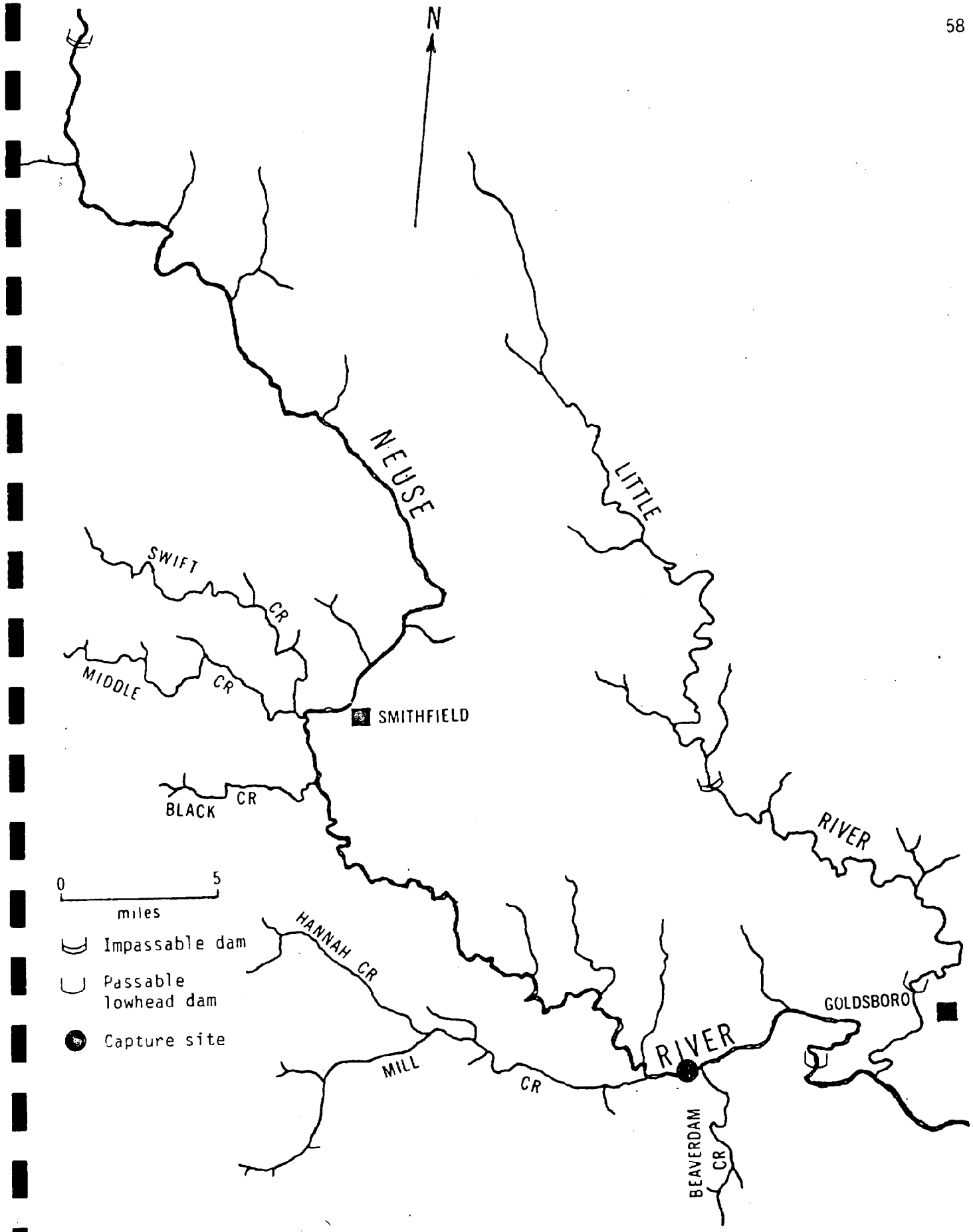

Figure 16 - continued.

Lapointe (1958) stated that young-of-the-year American shad remained in the fresh or brackish waters of the Neuse until October or November, when they migrated to the ocean. Godwin and Adams (1969) found that juvenile American shad left the Altamaha River, Ga when they reached 90 - 100 mm, usually during October-December. Neuse River juvenile shad catches also decreased noticeably during October (Figure 17). The highest catches of juvenile American shad were recorded in June and July.

Sampling produced no evidence of size-related movement of shad as found by Godwin and Adams (1969) in Georgia. The mean length of Neuse River American shad increased steadily from June-November, 1977-79, showing no sign of leveling off (Figure 18). Street, et al. (1975), and Godwin and Adams (1969) suggested that a flattened growth curve might indicate emigration of larger fish from the river system. Spitsbergen and Wolff (1974) found young American shad in the Neuse River as late as March, at a size range of 95 - 125 mm.

Godwin and Adams (1969) and Davis and Cheek (1967) reported that juvenile American shad movement was temperature related, with more shad emigrating out of the rivers as water temperatures dropped. Due to the unusually warm weather during Fall, 1977-79, Neuse River water temperatures were still relatively high in early November (15 - 19°C). The high temperatures may have delayed migration of juvenile shad out of the Neuse until early winter.

Growth - The mean fork length of each year class of juvenile American shad in the Neuse River during May-November, 1977-79 is shown in Figure 18, along with a growth curve combining all year classes. Sample sizes were quite small except for the 1978 year-class. Godwin and Adams (1969) reported a high growth rate for shad from the Altamaha River, GA. American shad from the Neuse River also exhibited rapid, steady growth.

Juvenile American shad in the Neuse River during May-November ranged from 31 - 95 mm; sizes very similar to those also found by Walburg (1956) in the Neuse River.

Hickory shad

During May-November, 1976-79, 916 juvenile hickory shad were collected in the Neuse River. Of this total, 905 juveniles were captured through supplemental sampling in May, 1977. These juveniles were captured in the area of Pitchkettle and Turkey Quarter Creeks (Figure 19), and averaged 27 mm in length. Marshall (1977)

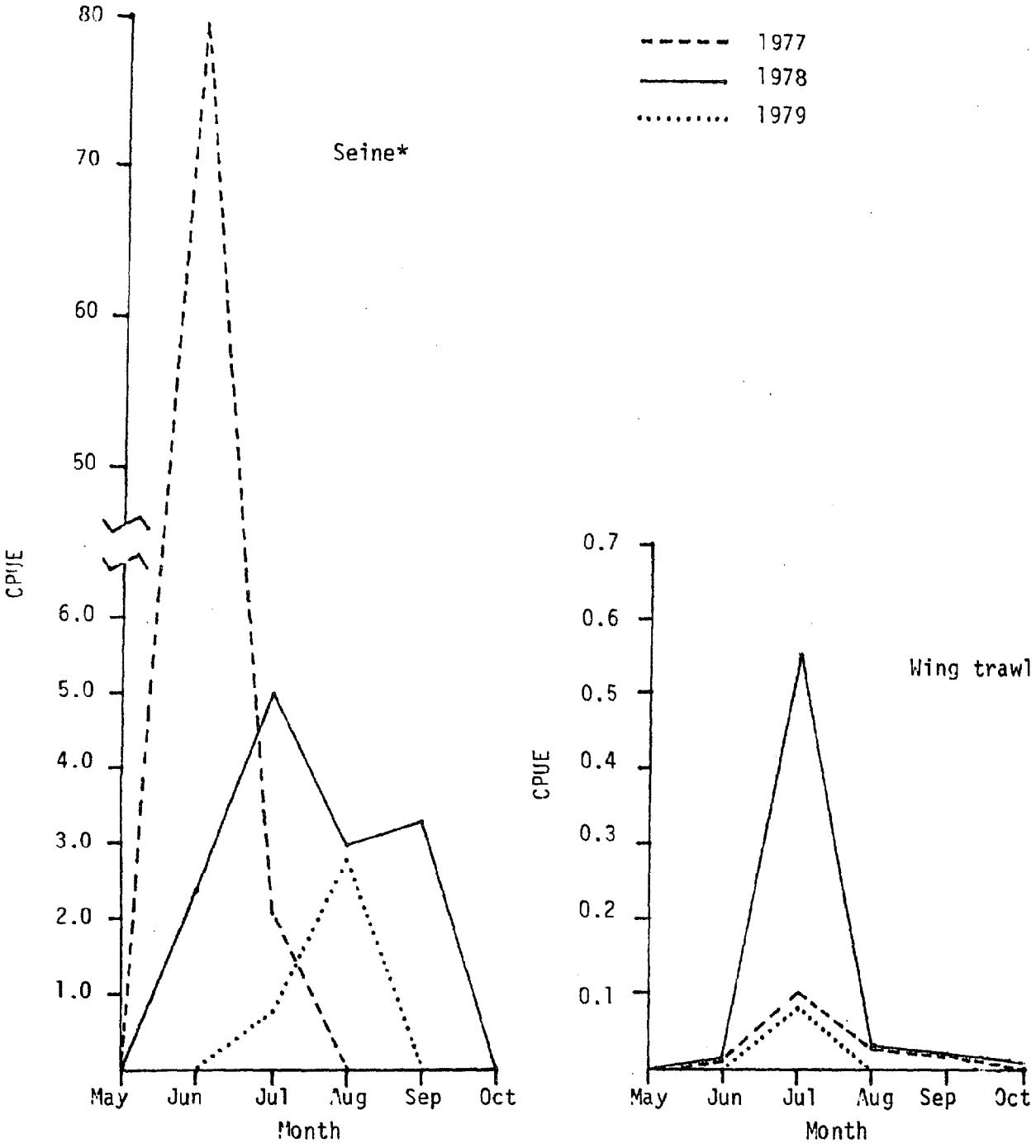

Figure 17 - Monthly catch per effort of juvenile American shad, Neuse River, May-October, 1977-1979.

*Stations above New Bern were used for seine data.

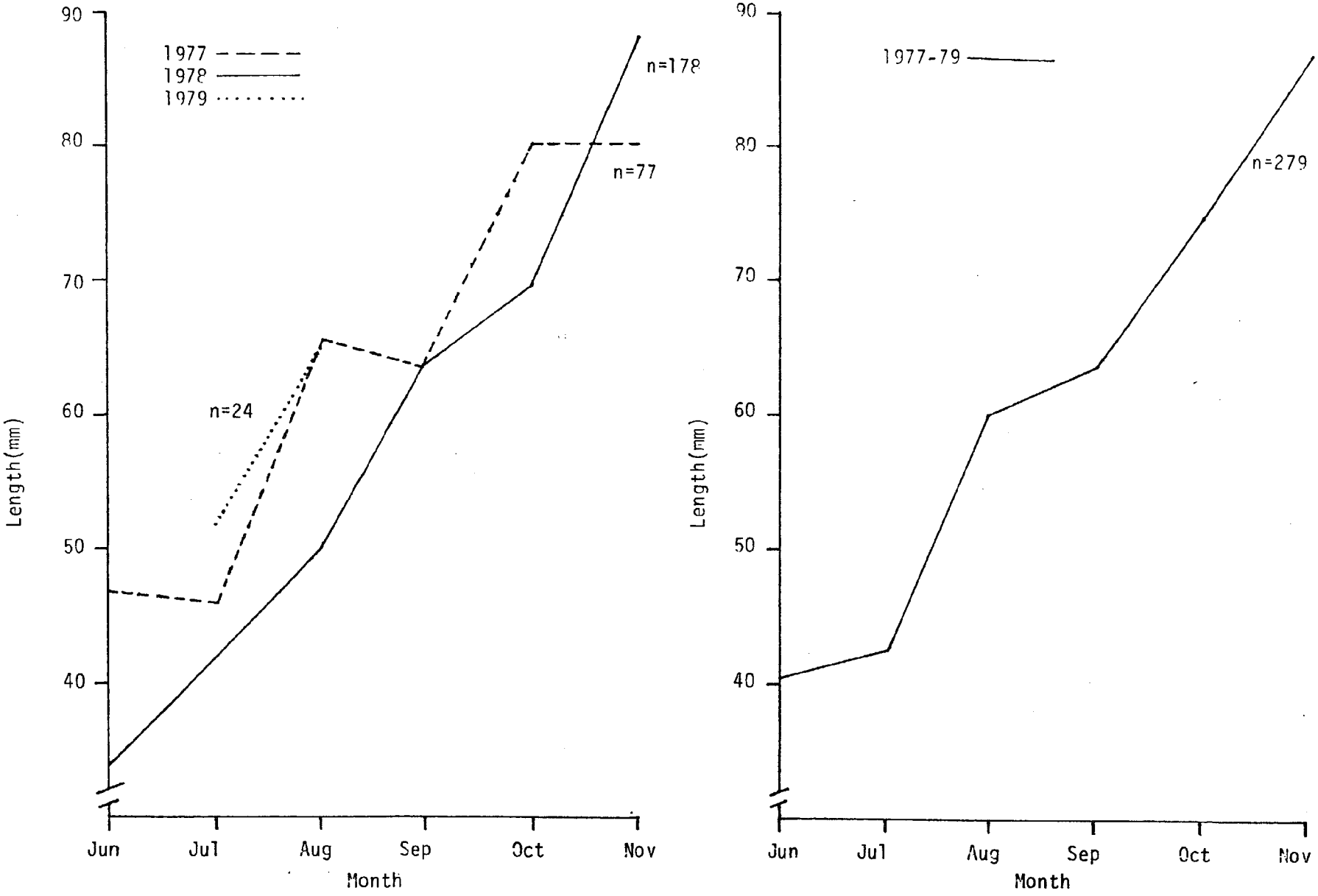

Figure 18. Mean fork length of juvenile American shad by month for the Neuse River, 1977-1979.

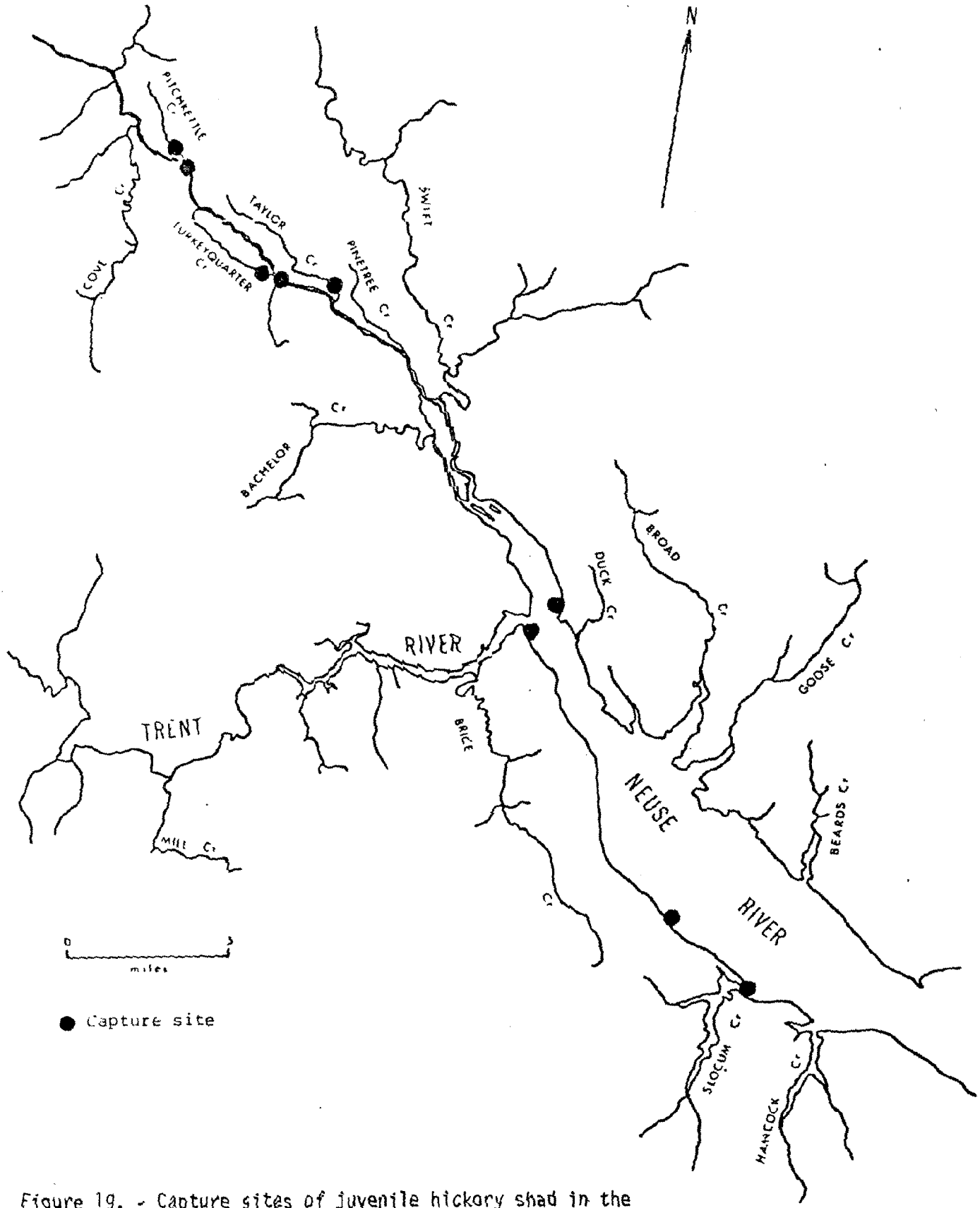

Figure 19. - Capture sites of juvenile hickory shad in the Neuse River, NC, 1977 - 1979.

and Pate (1972) reported that juvenile hickory shad spend only a short time in upstream nursery areas before migrating to brackish tributaries of the lower Neuse and Pamlico Sound. Sampling in May and early June produced the entire catch of juvenile hickory shad, with sizes ranging from 20 to 46 mm in May and 37 - 70 mm in June. Three juveniles were caught below New Bern at 45 - 70 mm, perhaps supporting the observation of Marshall (1977), that hickory shad migration in the Neuse River begins in June. Spitsbergen and Wolff (1974) also reported juvenile hickory shad in the Neuse, ranging from 85 to 90 mm, during July and August, 1973.

Striped bass

Only ten juvenile striped bass were collected from the Neuse River during the sample period; all during 1978 and 1979. Most were caught with beach seines below New Bern during July and August (Figure 20). The young striped bass (6) captured in 1978 are thought to be natural stock, while those captured in 1979 (4) were probably due to a stocking program by the NC Wildlife Resources Commission in July on the Neuse River. Although very few young striped bass were taken in 1978, those fish could have been indicative of a relatively successful spawning season when considered with the frequent catch of striped bass eggs during the spring of 1978 and the later catch of yearling striped bass in late fall, 1979. Also, no previous records of any juvenile striped bass catches from the Neuse River could be found during literature reviews.

Nursery areas of striped bass have been recognized in the Northeast Cape Fesr River (Sholar 1977) and Albemarle Sound region (Street and Johnson 1977). Preliminary nursery areas were also identified in the Tar-Pamlico River during 1978 (Hawkins 1979). The low catch of juvenile striped bass prevented definite conclusions on movement, growth, and relative abundance. Growth did appear to be quite rapid, with 35 - 65 mm fish being caught in July, and 75 - 85 mm fish b being caught in August. Juvenile striped bass appeared to show no preference for fresh or brackish water areas. Interestingly, most (70%) of the young striped bass from the Neuse were caught with a beach seine, usually over sand bottoms and near grass beds.

Although striped bass juvenile numbers were low, the catch in 1978 appears to be significant. No young striped bass had been reported previously in the Neuse River, thus the capture of juveniles in 1978 provides a preliminary picture of

striped bass nursery areas in the Neuse River. The juvenile catches from the Neuse River and also those found by Hawkins (1979) in the Tar-Pamlico River appear indicative of a successful striped bass spawning season in 1978, relative to previous years and 1979.

Atlantic sturgeon

Nine small Atlantic sturgeon were captured during January through March, 1977-79 during spring adult sampling and four were caught in October, 1978 from the Neuse River during supplemental gill net sampling (Figure 20). The sturgeon ranged in length from 370 - 700 mm. Information is very limited regarding the sturgeon population in the Neuse River, and commercial and recreational catches are quite small.

Adult Fish Sampling

Division Sampling

Adult anadromous fish were sampled by various methods in the Neuse River during 1976 - 79: Division of Marine Fisheries gill nets set in the main stream and tributaries, a haul seine, a pound net, examination of commercial landings in fish houses, and examination of recreational catches. Gill net sampling consisted of fishing over 1,042 yd (1,000 M) of gill net near the New Bern railroad trestle over the Neuse River during 1977-78. These nets were fished from mid-January through mid March each year and consisted of varying mesh sizes mentioned previously. Nets were also placed in creeks and tributaries to obtain scale camples from March - May, 1977 - 79. Nets were set in all the major tributaries except Clubfoot and Adams Creeks and South River in Craven and Carteret Counties, Southwest and Bear Creeks in Lenoir County, Walnut Creek in Wayne County, and Black Creek in Johnston County. Clubfoot and Adams Creeks and South River were not sampled due to extensive cropland alterations in the headwaters, while the other creeks were too shallow to sample with gill nets. Distribution of anadromous adults was found to generally correspond with spawning areas, and is discussed in some detail within the spawning area section (See RESULTS AND DISCUSSION - Spawning Areas).

Blueback herring

Blueback herring was by far the most abundant anadromous species inhabiting the tributaries of the Neuse River, being found in all major creeks and rivers

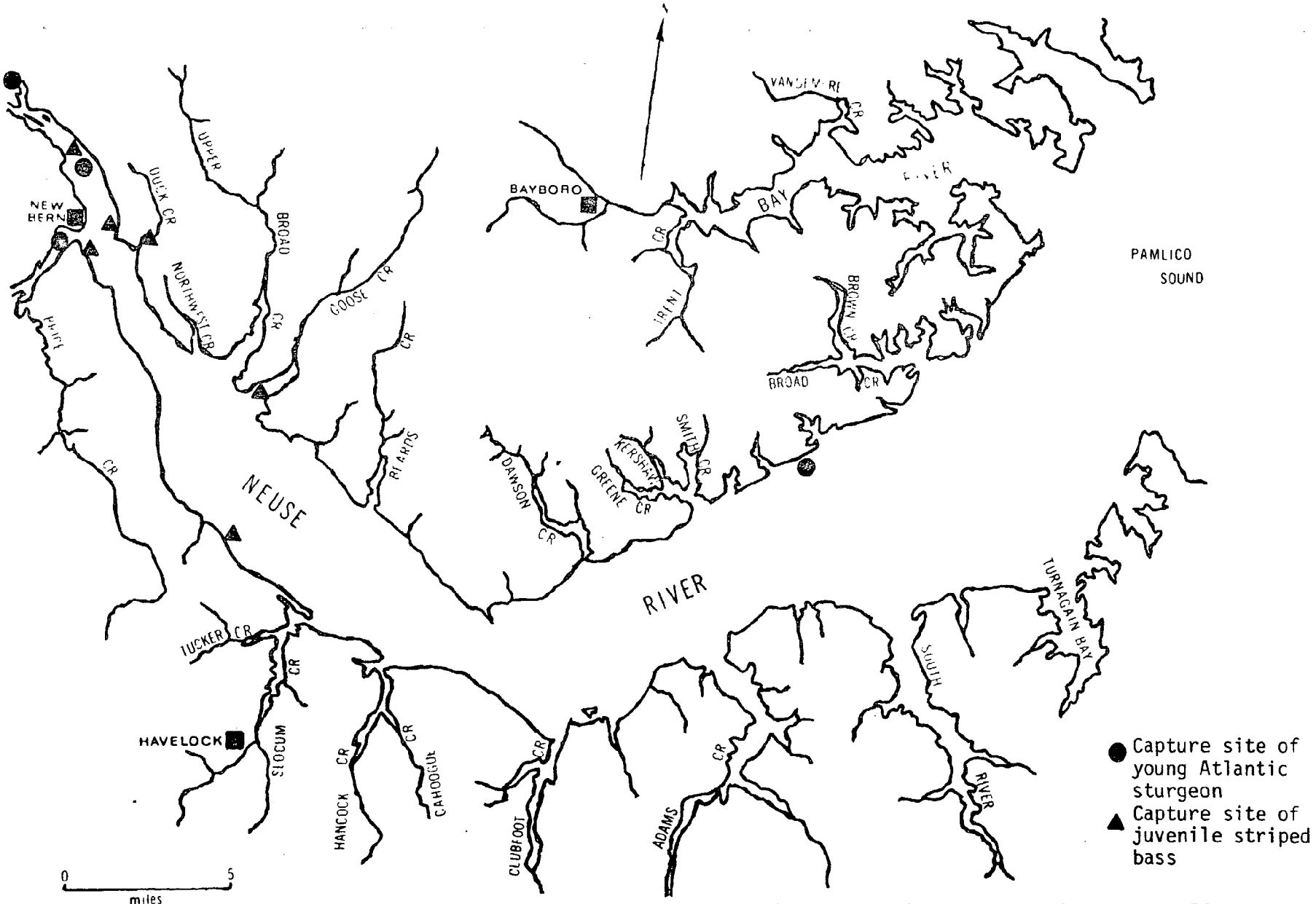

Figure 20 - Capture sites of juvenile striped bass and young Atlantic sturgeon in the Neuse River, NC, 1977-79.

between the mouth and Goldsboro, except Bay River and Broad, Goose, Northwest, and Falling Creeks, and those tributaries not sampled. The only tributary above Goldsboro where adult blueback herring were captured was Mill Creek. The most important spawning area for blueback herring in the lower Neuse was Brice Creek, a tributary of Trent River. Pitchkettle, Taylor, Turkey Quarter, and Swift Creeks were observed as being major adult habitats in the middle Neuse. In the upper Neuse River, Mill Creek is the most important spawning area. Blueback herring were also caught in the mainstem of the Neuse as early as February 21, at a water temperature of 5°C. Hildebrand (1963) reported that a water temperature of 12°C must be reached before blueback herring will enter a river.

During the entire study period (1977-79) 1,400 blueback herring scale samples were examined to determine age (Table 7). Annual age class composition of blueback herring during 1977-79 is shown in Appendix Tables 1-6. Blueback herring in the Neuse River ranged in age from three to eight years. Males were predominately four and five, and females, four, five, and six (Table 8). The proportion of repeat spawners found was high, as Marshall (1976) found in Pamlico River and Sound and Street at al. (1975) found in Albemarle Sound. Repeat spawning was almost equal for both sexes, with 52% of the males and 53% of the females showing evidence of previous spawning. Males exhibited as many as three spawning marks and females, four. The mean fork lengths for each age group are very similar to those found in other North Carolina investigations, especially those examined in the Tar-Pamlico River (Table 9).

Alewife

Only 170 alewife scale samples were suitable for age determination during 1977-79. These fish came from a combination of gill net sampling and commercial and recreational catches. Most of the alewife were caught in gill nets below New Bern, the major catch areas being Dawson and Slocum Creeks. In the middle Neuse, alewife were captured in Pitchkettle and Taylor Creeks and in the upper Neuse, in Beaverdam Creek. Alewife was the dominant river herring species in the lower Neuse, apparently preferring the higher salinities of the area. Sholar (1977) and Bigelow and Welsh (1925) noted similar preferences in the Cape Fear system and the New England area, respectively. The early river herring spawning runs were compsed primarily of alewife, similar to what Hildebrand and Schroeder (1927) found in Chesapeake Bay and Johnson, et al (1977 noted in Albemarle Sound.

Table 7 Age and spawning frequency of blueback herring in the Neuse River, NC, 1977-79

Spawning marks	0		1		2		3		4		Total	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Age												
III	30	8									30	8
IV	294	198	50	5							344	203
V	55	81	219	156	43	4					317	241
VI			5	27	77	74	8	5			90	106
VII						10	12	27			12	37
VIII						1		4		7	0	12
Total	379	287	274	188	120	89	20	36	0	7	793	607
Percent	48	47	35	31	15	15	2	6	0	1		

Table 8 Size and age composition of blueback herring in the Neuse River, NC, 1977-79

Age	Total number		Percent of samples		Mean fork length(mm)		Length range(mm)	
	M	F	M	F	M	F	M	F
III	30	8	4	1	237	245	225-258	230-262
IV	344	203	43	33	247	253	230-266	230-271
V	317	241	40	40	251	263	230-295	240-289
VI	90	106	11	18	262	272	242-278	257-289
VII	12	37	2	6	265	278	251-271	260-300
VIII	0	12	0	2	-	287	-	278-300
	793	607						

Table 9 - Age and mean length of blueback herring examined during the present study compared to other North Carolina Investigations.

Age	3		4		5		6		7		8	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Location	Fork length (mm)											
Neuse River	237	245	247	253	251	263	262	272	265	278	-	287
Tar-Pamlico River	232	-	244	254	256	264	261	270	264	285	-	290
Tar-Pamlico River[1]	239	242	240	249	251	257	263	275	-	280	-	291
Northeast Cape Fear River[2]	231	239	242	247	253	262	264	275	-	275	-	-
Cape Fear River[3]	-	-	255	266	259	270	287	279	-	290		
Albemarle Sound[4]	229	244	237	248	247	257	251	264	259	270	270	280

[1]Marshall, 1976
[2]Sholar, 1977
[3]Fischer, 1979
[4]Street, Pate, Holland, and Powell, 1975

Most of the alewife samples were four, five, and six years old (Table 10). Males were predominately (80%) four and five years old and females (66%), five and six (Table 11). Joseph and Davis (1965) found similar alewife ages in lower Chesapeake Bay. Three-year old fish comprised almost 4% of the alewife sampled, somewhat lower than found by Johnson, et al. (1977) and Street, et al. (1975) in Albemarle Sound. Samples were dominated by older females, as indicated by a high percentage (61%) of female repeat spawners. Thirty-one percent of the male alewife sampled exhibited evidence of previous spawning. Johnson, et al. (1977) reported that only seven percent of the alewife sampled (sexes combined) in Albemarle Sound had spawned previously.

American shad

Most of the scales taken from American shad for age analysis were sampled at commercial fish houses on the Neuse (MATERIALS AND METHODS Section - Adult Fish Harvest). Therefore, age and size composition of American shad are discussed in the commercial fishery section.

Hickory shad

Scales from 692 hickory shad were found suitable for age determination during 1977-79. Yearly age composition is shown in Tables 7-12 of the Appendix. The majority of the hickory shad sampled were captured in the Division's gill nets, with very few being observed in commercial catches. Hickory shad were captured predominately during February and early March, being the first anadromous species to migrate up Neuse River each spring. Most of the fish were caught at a temperature range of 5-15°C.

Hickory shad ranged from age II to age VIII (Table 12). Most of the males were three and four year old olds, while most females were three, four, and five (Table 13). Pate (1972) found a higher incidence of two year old males in the Neuse River; however the mean fork lengths for each year-class generally agree, indicating that our sampling gear was probably selective for larger males. Pate (1972) also reported that the female hickory shad population was composed mainly of three, four, and five year olds. Average fork lengths by age-class are compared to other North Carolina investigations in Table 14.

Table 10 Age and spawning frequency of alewife in the Neuse River, NC, 1977-79

Spawning marks	0		1		2		3		4		Total	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Age												
III	7										7	0
IV	41	12	1								42	12
V	16	18	15	5	2						33	23
VI			1	14	7	13		1			8	28
VII					2	7	1	4			3	11
VIII								2		1	0	3
Total	64	30	17	19	11	20	1	7	0	1	93	77
Percent	69	39	18	25	12	26	1	9	0	1		

Table 11 Size and age composition of alewife in the Neuse River, NC, 1977-79

Age	Total number		Percent of samples		Mean fork length(mm)		Length range(mm)	
	M	F	M	F	M	F	M	F
III	7	0	8	0	245	-	237-252	-
IV	42	12	45	16	248	255	238-264	245-270
V	33	23	35	30	256	264	245-270	241-275
VI	9	28	9	36	268	273	260-275	262-290
VII	3	11	3	14	278	282	275-294	257-298
VIII	0	3	0	4	-	289	-	287-291
	93	77						

Table 12 Age and spawning frequency for hickory shad in the Neuse River, NC, 1977-79

Spawning marks	0		1		2		3		4		5		Total	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Age														
II	14	4											14	4
III	63	91	32	5									95	96
IV	22	78	83	99	23	5							128	182
V	1	3	2	15	36	55	4	3					43	76
VI						8	6	12	6	1			12	21
VII								1	4	11	1		5	12
VIII											1	3	1	3
Total	100	176	117	119	59	68	10	16	10	12	2	3	298	394
Percent	34	45	39	30	20	17	3	4	3	3	1	1		

Table 13 Size and age composition of hickory shad in the Neuse River, NC, 1977-79

Age	Total number		Percent of samples		Mean fork length(mm)		Length range(mm)	
	M	F	M	F	M	F	M	F
II	14	4	5	1	295	302	272-323	296-307
III	95	96	32	24	318	337	260-352	280-380
IV	128	182	43	46	342	360	310-378	325-400
V	43	76	14	19	353	373	325-405	321-407
VI	12	21	4	5	374	393	320-400	363-420
VII	5	12	2	3	384	413	372-392	388-440
VIII	1	3	<1	1	397	410	-	400-421
	298	394						

Table 14 - Age and mean length of hickory shad examined during the present study compared to other North Carolina investigations.

Age	2		3		4		5		6		7		8	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Location														
Neuse River	295	302	318	337	342	360	353	373	374	393	384	413	397	410
Neuse River[1]	294	311	332	354	346	376	356	395	357	409	369	420	-	-
Pamlico Sound[2] and River	286	290	297	324	341	354	355	376	395	413	-	427	-	-
Albemarle Sound[3]	289	341	325	341	350	355	371	387	360	384	365	390	-	-

[1]Pate, 1972

[2]Marshall, 1976

[3]Street, Pate, Holland, and Powell, 1975

Repeat spawning was very high for hickory shad in the Neuse River, as documented by Pate (1972). Sixty-six percent of the males and 55% of the females had one or more spawning marks on their scales. The percentage of repeat spawners in other areas of North Carolina is also high, with Pamlico River and Albemarle Sound showing 50% and 49% respectively (Marshall 1976; Street, et al 1975).

Striped bass

Only 173 striped bass scale samples were examined for age composition from the Neuse River during the study. Ages ranged from one to ten years (Table 15). Most of the striped bass encountered (84%) were from one to five years old, with a length range of 305-658 mm. Adult sampling indicated that the striped bass population in the Neuse River was very low during 1977-79, as very few fish were encountered during intense spring and fall net fishing and commercial fish house sampling.

Commercial Fishery Sampling

The commercial fishery of the Neuse River has historically contributed only slightly to the total North Carolina landings of anadromous fish (Table 1). The area of the Neuse River that can be fished commercially extends from the mouth of the river to the mouth of Pitchkettle Creek, a total of 55 mi (89km). The principal commercial gear utilized for anadromous fish from New Bern downstream is the staked gill net, set primarily for American shad and striped bass. Walburg (1953) reported that the predominant gears used in the commercial anadromous fishery were staked and drift gill nets, haul seines, and pound nets. Pound nets were historically utilized as the principal gear for harvesting American shad in the lower Neuse; however, in recent years pound nets have been set primarily for non-anadromous species. Haul seines were reported by Walburg (1953) between New Bern and Pitchkettle Creek in the middle section of the Neuse River. However, only one haul seine was operated on the Neuse during 1977-79, with only moderate success.

American shad

Walburg and Nichols (1967) stated that the Neuse River was the most important shad stream between the St. John River, FL and the James River, VA in 1896. Since

Table 15 - Age frequency, mean length, and length range of striped bass from the Neuse River, NC, 1976-79.

Fall 1976-78		Spring 1977-79		Mean fork length (mm)		Length range (mm)	
Age	Total no.	Age	Total no.	Fall	Spring	Fall	Spring
I*	27	II	8	370	362	326-403	305-427
II*	27	III	24	424	420	390-475	330-458
III*	13	IV	24	466	466	400-500	400-587
IV*	10	V	12	542	535	505-568	498-625
V*	7	VI	6	587	569	530-658	522-645
VI*	2	VII	8	631	630	627-635	550-748
VII*	1	VIII	0	630	-	-	-
VIII*	0	IX	3	-	767	-	745-895
IX*	0	X	1	-	785	-	-
	87		86				

*aged during growth period

1960 American shad landings in the Neuse River have accounted for an average of 16% of the total North Carolina shad catch (Table 16). This proportion may be misleading, for fish from outside areas are sometimes sold to Neuse River fish dealers; however, shad from the Neuse are also sold to dealers in other areas. Therefore, these landings are the best estimate of commercial catch available.

The primary gears for harvesting American shad in the Neuse River are staked and drift gill nets. Staked gill nets are usually set in 91.4 m (100 yd) sections, composed of 124 mm (4 7/8 in) or 140 mm (5 1/2 in) stretched mesh. The staked nets are primarily utilized between New Bern and the mouth of the river. Shad fishing in this area usually begins in late January and continues into March. Drift gill nets are mainly used from the Flowers Gap area just above New Bern to Pitchkettle Creek. The nets range from 23 to 91.4 m (25 to 100 yd) long with 125 mm (4 7/8 in) or 140 mm (5 1/2 in) stretched mesh. Most of the American shad caught with drift nets are used for personal consumption; the excess is usually sold commercially.

Sampling of the commercial harvest for American shad was initiated in early February at three locations in the study area. However, no shad were usually encountered until mid-February. Fish houses at Oriental and on Broad Creek provided most of the samples for the Neuse River (Figure 5).

Scales from 1,094 American shad were found suitable for age determination during 1977-79. Annual age-size composition for 1977-79 can be seen in Tables 13-18 in the Appendix. Ages ranged from three to seven for males, and four to eight for females (Table 17). Age groups four and five made up 85% of the males sampled, very close to the 88% found by Johnson, et al, (1977) in Albemarle Sound. Females were predominately (92%) five and six year old (Table 18), again appearing similar to the 88% reported by Johnson, et al, (1977). Only 7.4% of the American shad observed had spawned previously, agreeing with Walburg's (1953) assumption that very few shad spawn repetitively below Cape Hatteras. Walburg (1953) found that three percent of the Neuse River shad he examined were repeat spawners. Chitterden (1975) found that only three percent of the shad he examined from the Delaware River had spawned previously. Ninety-one percent of the males and 93% of the females from the Neuse River were virgin fish during the present study.

Mean lengths of Neuse River American shad are compared with those of other investigations in Table 19. The bulk of the female American shad harvested during

Table 16 - Relative importance of American shad and hickory shad in the Neuse River, NC, as shown by commercial landings (from unpublished data: NC Division Marine Fisheries and NMFS).

Year	American shad NC (lb)	American shad Neuse River (lb)	% American shad Neuse River	Hickory shad NC (lb)	Hickory shad Neuse River (lb)	% Hickory shad Neuse River
1960	507,000	104,300	21	180,703	41,600	23
1961	673,000	140,800	21	276,437	69,100	25
1962	765,000	126,600	17	171,650	59,100	34
1963	693,000	71,400	10	292,000	91,200	31
1964	640,000	159,800	25	232,000	30,900	13
1965	1,069,000	254,900	24	202,000	53,700	27
1966	701,000	113,449	16	196,596	87,806	45
1967	777,000	110,700	14	130,574	32,600	25
1968	840,000	86,300	10	141,305	49,700	35
1969	719,000	173,100	24	100,716	16,600	16
1970	953,000	91,000	10	61,424	15,500	25
1971	680,000	110,600	16	62,800	21,600	34
1972	468,000	81,800	17	69,190	5,400	8
1973	321,000	69,500	22	65,973	11,700	18
1974	368,000	61,100	17	41,725	1,800	4
1975	241,000	27,700	11	29,202	2,100	7
1976	167,000	34,100	20	18,716	3,200	17
1977	121,022	6,100	5	22,109	3,100	14
1978	402,017	31,746	8	20,507	5,600	27
1979	278,070	31,600	11	31,716	3,100	10

Table 17 Age and spawning frequency of American shad in the Neuse River, NC, 1977 - 1979.

Spawning marks	0		1		2		3		Total	
Sex	M	F	M	F	M	F	M	F	M	F
Age										
III	16								16	0
IV	121	46	5	1					126	47
V	137	429	13	18	1				151	447
VI	23	235	2	22	5	6			30	263
VII		5		5	1		2		3	10
VIII		1							0	1
Total	297	716	20	46	7	6	2	0	326	768
Percent	91	93	6	6	2	1	1	0		

Table 18 Size and age composition of American shad in the Neuse River, NC, 1977 - 1979.

Age	Total number		Percent of samples		Mean fork length(mm)		Length range(mm)	
	M	F	M	F	M	F	M	F
III	16	0	5	0	370	-	347-397	-
IV	126	47	39	6	401	428	348-452	368-463
V	151	447	46	58	418	460	369-455	403-505
VI	30	263	9	34	435	482	408-472	430-582
VII	3	10	1	1	455	502	438-484	460-526
VIII	0	1	0	1	-	547	-	-
	326	768						

Table 19 - Age and mean length of American shad examined during the present study compared to other North Carolina investigations.

Age	3		4		5		6		7		8	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Location												
Neuse River	370	-	401	428	418	460	435	482	455	502	-	547
Pamlico Sound and River	-	-	404	429	425	464	452	486	-	523	-	-
Neuse River[1]	368	376	422	429	-	472	-	513	-	-	-	-
Neuse River[2]	393	-	420	448	445	450	-	503	-	-	-	-
Pamlico Sound and River[3]	334	-	415	445	437	481	456	494	470	489	485	532
Albemarle Sound[4]	359	-	400	437	432	473	450	498	461	540	476	509

[1]Lapointe, 1958, calculated fork length in inches to mm

[2]Hassler, W. W. and Pate, P.P., Jr. (unpublished data, Zoology Department, NC State University at Raleigh)

[3]Marshall, 1976

[4]Street, Pate, Holland, and Powell, 1975

1977-79 with gill nets ranged from 430-490 mm (Figure 21); a range very similar to that found by Sholar (1977) in the Northeast Cape Fear River. Length data from the commercial catch showed a gradual increase in the percentage of 460 mm females from 1977-79, indicating a greater dependence on five year-old females. Males were harvested at a significantly smaller size range, predominanaly 390-430 mm. The male shad commercial harvest during 1977 exhibited a lesser dependence on a particular size range than those harvested in 1978 and 1979.

Hickory shad

The contribution of Neuse River landings to North Carolina's commercial catch of hickory shad has varied from four to forty-five percent during 1960-1979 (Table 16). During 1968-79 commercial landings from the Neuse River comprised an average of 19% of the catch. Reported Neuse River hickory shad landings steadily decreased from a peak of 91,200 lb in 1963 to only 3,900 lb in 1977. Landings rose slightly again in 1978 to 5,600 lb, but then dropped again in 1979 to 3,100 lb (unpublished data NC Div. Mar. Fish. and NMFS).

The commercial value of hickory shad is limited, mainly due to a lack of a market for the species. The commercial catch consists mainly of large females taken as a by-catch of the American shad fishery, and small males caught with river herring nets. The recreational catch of hickory shad is thought to far exceed the commercial catch, with most of the fish being caught by drift gill nets or hook and line.

River herring

The commercial harvest of river herring is insignificant in the Neuse River. Only 1,100 lb of river herring have been reported in the Neuse River since 1975 (unpublished data, NC Div. Mar. Fish. and NMFS). Most of the alewife and blueback herring captured in inland waters are for personal consumption.

Striped bass

The striped bass commercial fishery is also very small in the Neuse River. Gill nets are the most common commercial gear used to capture striped bass, being set in late winter and early spring. However, most of the striped bass caught are taken by recreational fishermen for personal consumption. No striped bass have been reported in the commercial catch since 1976.

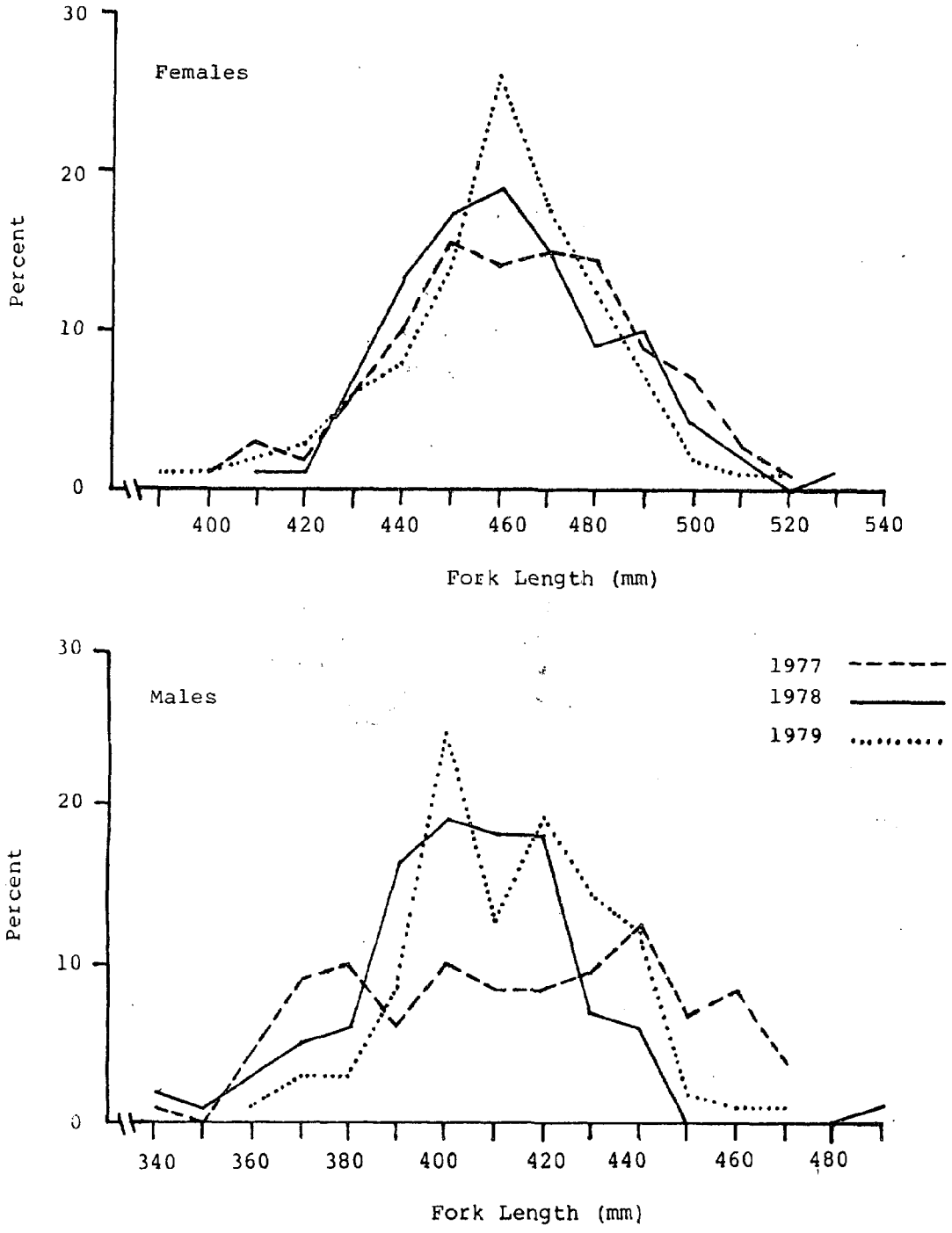

Figure 21 - Fork length frequency of commercially harvested American shad, Neuse River, NC, 1977 - 1979.

Sturgeon

Very few Atlantic sturgeon are landed commercially in the Neuse River; those caught are usually the by-catch of other fisheries.

Recreational Fishery Sampling

The inland recreational fishery for anadromous fish officially extends from the mouth of Pitchkettle Creek to Raleigh (Figure 3). Pitchkettle Creek represents the dividing line between the jurisdictional areas of the Division of Marine Fisheries and the Wildlife Resources Commission. However, extensive recreational fishing occurs between New Bern and Pitchkettle Creek. Most of the fishing pressure for anadromous fish in this area is via drift gill nets and hook and line. Other gears used in the inland fishery include set gill nets, bow nets, haul seines, and fish wheels.

According to Baker (1968), the Neuse River provided the largest and most productive recreational fishery for American shad and hickory shad in North Carolina. He found that the Neuse River sustained more fishing pressure via special devices (bow nets, gill nets, seines) than any other coastal river, with over 2,100 fishermen making almost 20,000 fishing trips to take anadromous fish in 1967. Baker reported that 60,552 hickory shad, 75,098 American shad, and 351,577 pounds of river herring were captured during the 1967 spawning season. The recreational catch of American and hickory shad was more than the catch from all other coastal streams combined. Over 1,000 striped bass were also taken from the Neuse River during that period.

Lower Neuse River

Recreational fishing for anadromous fishes in the Neuse River below New Bern is limited mainly to dip-netting activity for river herring and hook-and-line fishing for striped bass. Dip-netting was reported at only two locations in the lower Neuse River, with the SR 1746 bridge over Slocum Creek in Havelock (Figure 6) appearing to be the most popular location. The NC highway 55 bridge over upper Broad Creek had been reported as an excellent dip-netting site in the past, but in recent years has been unproductive.

Sport fishing for striped bass occurs in the New Bern area during the fall and early spring. Artificial baits are usually trolled or cast along the railroad and highway bridges near New Bern. Sections of river herring are also used as cut bait to catch striped bass. Stripers taken in this area usually range from two to ten pounds.

Trent River

The recreational fishery in the Trent River involves using gill, dip, and bow nets, and hook-and-line for river herring, American shad, and striped bass. However, fishing areas are limited by the lack of access points above Pollocksville, therefore, bridges serve as the major fishing areas.

River herring are the main species caught with gill and dip nets in the Trent River. Set gill nets were observed in Brice Creek and in the Trent River near the NC highway 58 bridge (Figure 6). No staked nets were observed; all were tied to trees and shoreline brush. Dip-netting for river herring occurs at the SR 1153 bridge at Pleasant Hill. This is probably the uppermost limit of fishing activity in the area. Several bridges on Brice Creek offered excellent locations, but activity at these sites was neither reported nor observed.

Hook-and-line fishing for American shad is popular in the Trent River, with three fishing locations reported; the SR 1129, the SR 1130, and the NC highway 58 bridges. Bow nets are also utilized in these areas to capture American shad. Set gill nets for shad were only observed below the NC highway 58 bridge (Figure 6).

Fishermen using cut bait for striped bass were encountered in the Trent River below Pollocksville during the spring. Striped bass were also taken in the lower Trent with artificial baits at other times of the year.

Upper Neuse River

Recreational fishing was observed in numerous areas throughout the region from New Bern to several miles above Goldsboro. Perhaps the most popular type of sport fishing during the spring spawning run is hook-and-line fishing for hickory shad. Marshall (1977) stated that the Neuse River was probably the most popular sport fishing area for hickory shad in North Carolina. Baker (1968) found that

60% of North Carolina hickory shad caught with hook and line were taken in the Neuse River by sport fishermen during 1 April 1967 to 31 March 1968. Pitchkettle Creek is the most popular sport fishing area for hickory shad in the Neuse River. Pate (1972) conducted a creel census at Pitchkettle Creek and found that 3,230 hickory shad were caught in the creek during 1970. Hickory shad are usually caught by sport fishermen casting or trolling with artificial lures (spoons and darts) in the still tributaries and flooded swamps away from the main river channel. Turkey Quarter and Contentnea Creeks are also popular hickory shad sport fishing areas.

Hook-and-line fishing for striped bass is also popular on the Neuse River between New Bern and Goldsboro. Fishermen in the New Bern area usually troll for striped bass with artificial lures during the spring and fall. One of the more popular fishing areas for trolling is the Flower's Gap area, between New Bern and Batchelor Creek (Figure 12). Further upstream, fishermen use modified bottom rigs baited with cut fish, preferably river herring, to catch striped bass during the spawning run. Sport fishermen usually fish near obstructions in the deeper sections of the river. However, striped bass are also caught in the larger creeks of the Neuse River, especially Swift Creek. One of the more popular sport fishing areas is the striped bass spawning grounds from Kinston to Goldsboro (Figure 11).

Another important recreational activity in the Neuse River is drift gill netting for American shad, hickory shad, and river herring. Drift netting activity usually begins in late February or early March when the anadromous species begin their spawning runs. Various mesh sizes are utilized for each species; 63.5 mm (2 1/2 in) and 72.9 mm (2 3/4 in) stretched mesh for river herring, 82.5 mm (3 1/4 in) and 101.6 mm (4 in) stretched mesh for hickory shad, and 123.7 mm (4 7/8 in) and 139.7 mm (5 1/2 in) stretched mesh for American shad. Popular areas for drift netting include the area close to the mouth of Swift Creek, the mouth of Pinetree Creek (Spring Garden), and the Pitchkettle Creek area (Figure 3). Drift netting is a socially significant activity on the Neuse River, with large crowds of people from the community and surrounding areas gathering to catch fish and eat. Often the fish caught in excess of those desired for personal consumption are sold to the public.

Other devices such as bow nets and dip nets are not as popular now as in the past. Bow nets were only reported on the Neuse River near Goldsboro and dip netting was limited to some of the smaller tributaries of the Neuse River. One haul seine was operated from the first week in April through May near Pitchkettle

Creek during 1977 and near the SR 1470 bridge in 1978-79 (Figure 5). Very few anadromous fishes were caught with the haul seine during 1978-79, although relatively good catches were encountered in 1977.

Two fish wheels were operated on Contentnea Creek (Figure 22). One fish wheel operated at the NC 123 was sampled several times; however, only a small number of river herring were caught. Reports from local fishermen indicated that the catch at the fish wheel below the NC 123 bridge was also very small. The principal species sought with these wheels were river herring and hickory shad.

Tagging

Tagging of anadromous fish in the Neuse River began in early October, 1976, with efforts directed toward capturing striped bass using the drop-net method. The tagging program has continued on the Neuse River with annual drop-net tagging in the fall, and gill net or pound net tagging in the late winter and early spring.

Fall tagging utilizing the drop-net has not been very successful since 1976. Only nine striped bass total were tagged during the fall seasons of 1977 and 1978, compared to 68 tagged during the Fall, 1976. Net drops were most successful when made along the railroad and highway bridges at New Bern.

Tagging from set gill nets began in early January and continued through late March during 1977 and 1978. Nets were set initially near the railroad bridge at New Bern and fished daily. During 1978 additional nets were placed in the Neuse River tributaries as the anadromous fish migrated upstream. Six sizes of monofilament webbing were used to capture each anadromous species (See MATERIALS AND METHODS-Spawning Area Sampling). Only fish in good condition were tagged and released. The nets were removed when catches became low and mortalities increased.

A pound net was set to tag anadromous fish during the spring of 1979 near Greene Creek in the lower Neuse River (Figure 3). Very few fish were caught by the pound net.

A haul seine was also used to tag fish near Pitchkettle Creek during 1977 and near the SR 1470 bridge during 1978-79 (Figure 5). The seine was fished one day per week during mid-March - April. Catches were excellent during 1977, but dropped significantly after the seine was moved to the SR 1470 bridge. The haul seine was

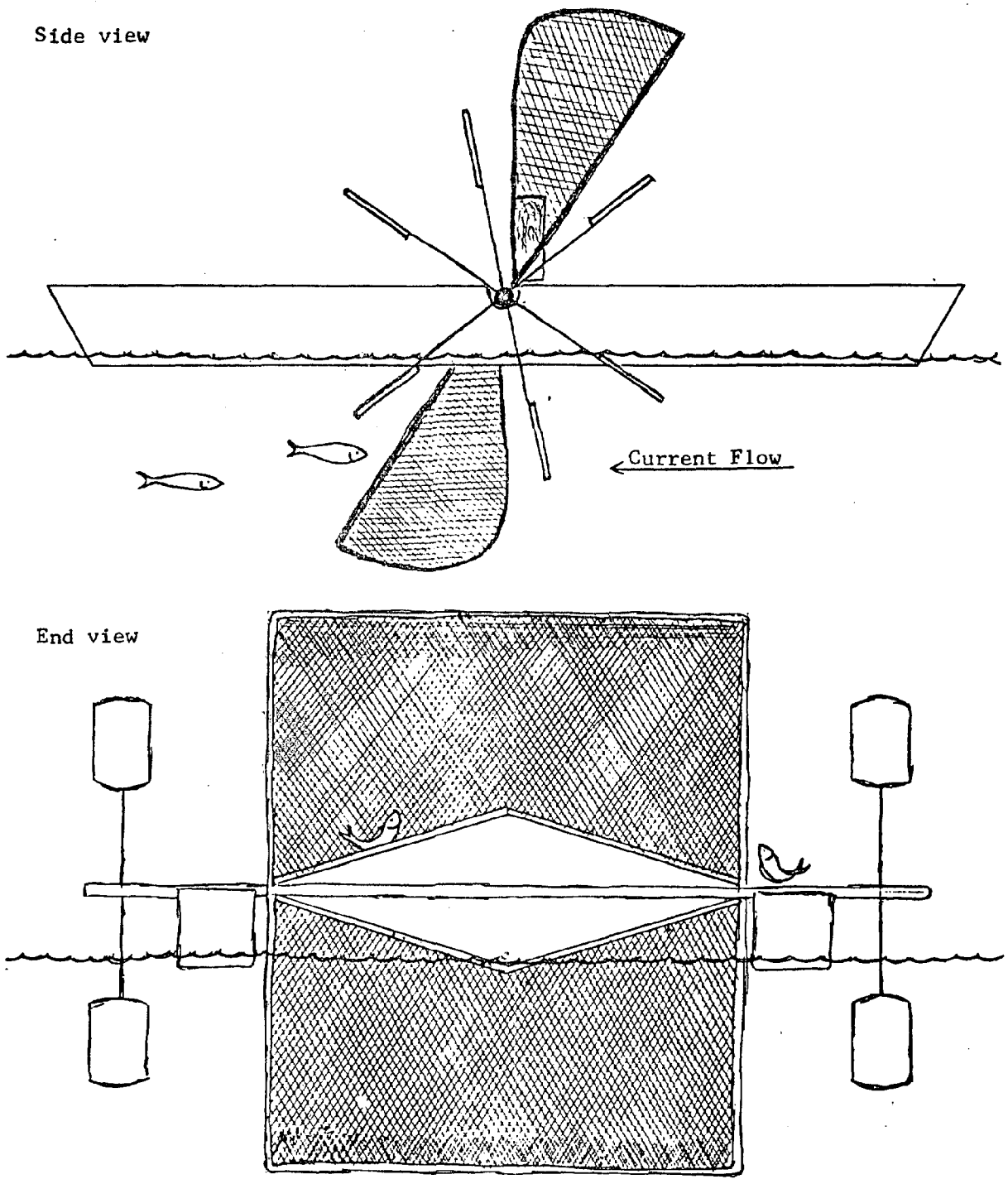

Figure 22. - Floating fish wheel

not rented during 1979 due to the poor results of the previous year, but was checked weekly during March-April to monitor catches.

A total of 37 striped bass, 39 American shad, 393 hickory shad, 311 blueback herring, eight alewife, and 13 Atlantic sturgeon was tagged during the spring seasons of 1977-79.

Striped bass

From the 114 striped bass tagged during Fall, 1976-Spring, 1979, 18 tags (15.8%) were returned. The number of returns was insufficient to show any definite pattern of movement. However, ninety percent of the returns were recaptured within 15 mi (25 km) of the tagging sites, with some fish at large for as long as 160 days. Apparently most of the tagged striped bass remained in the vicinity of New Bern (Figure 23). The tendency of striped bass of the Pamlico Sound system to remain in their native streams has been documented by Marshall (1976). Three returns were reported outside a ten mile radius from the tagging sites. One striped bass, recaptured near Slocum Creek (about 13 mi (21 km) from the tagging site) was at large only two days. Another striper was recaptured in the spring of 1979 near Goldsboro, having traveled approximately 100 mi (167 km) in 198 days. The fish was four years old and may have been on a spawning run. The last tag was returned from near the midpoint of the Pamlico River, representing the only evidence of striped bass exchange between the Neuse and Tar-Pamlico Rivers. That five-year old striper was also recaptured in Spring 1977, after being out for 32 days. The age distribution of the total tagged striped bass from 1977-79 was from four to ten years in age.

American shad

The number of American shad tagged and the number recaptured were also insufficient to show any pattern of movement. Of the 39 fish tagged, (15.4%) were returned (Figure 24). All the fish recaptured exhibited upstream movement after tagging, averaging 28 mi (46 km) traveled between tagging and recapture. Two shad tagged near Green Creek were later recaptured in the Pitchkettle Creek area, traveling approximately 45 miles (75 km). One shad traveled approximately 50 mi (83.5 km) from the Cove Creek area to Goldsboro in 12 days. All the shad were recaptured by various devices, including hook and line and drift gill net. The

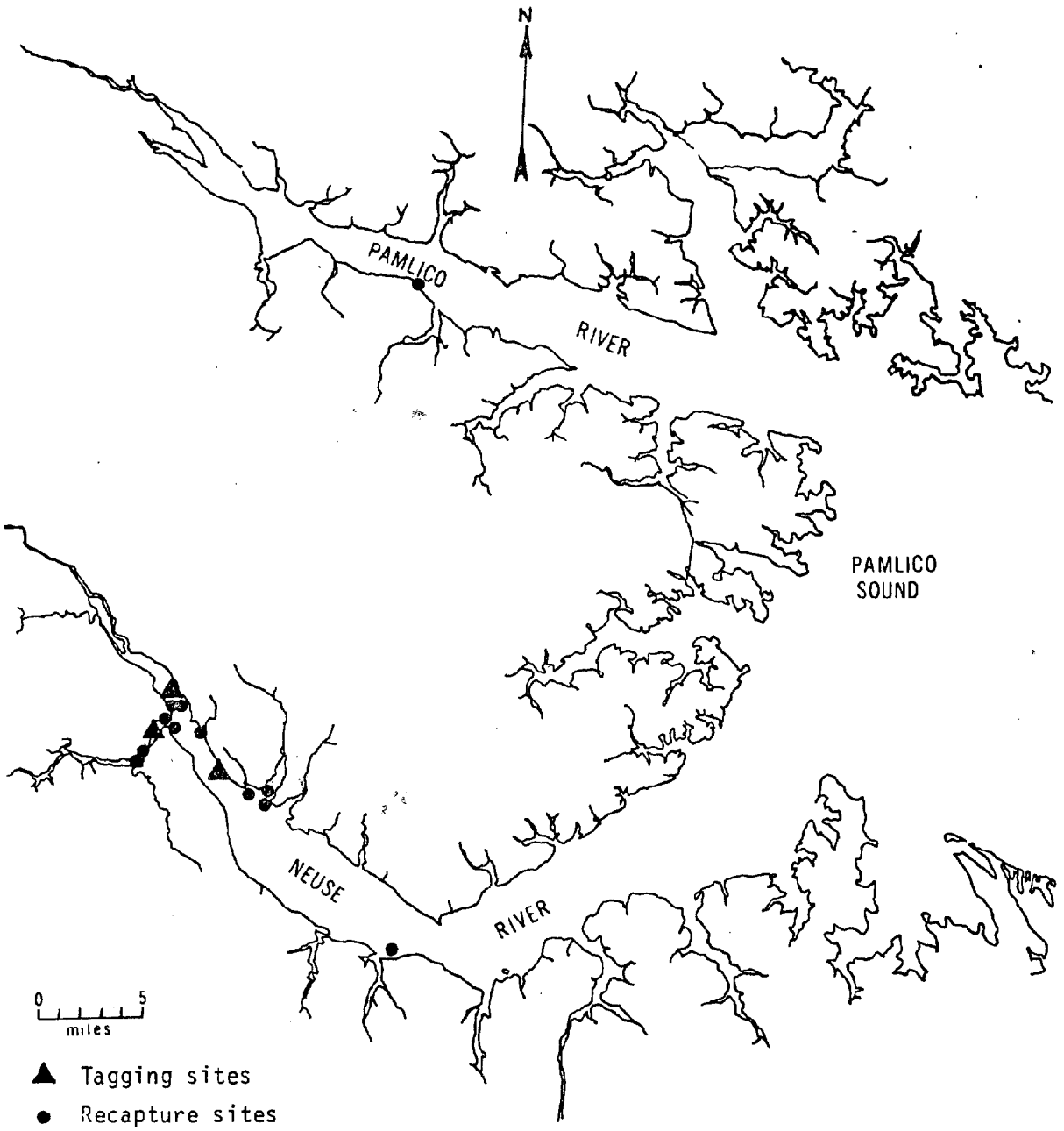

Figure 23 - Tagging sites and return locations of striped bass, 1976-1979.

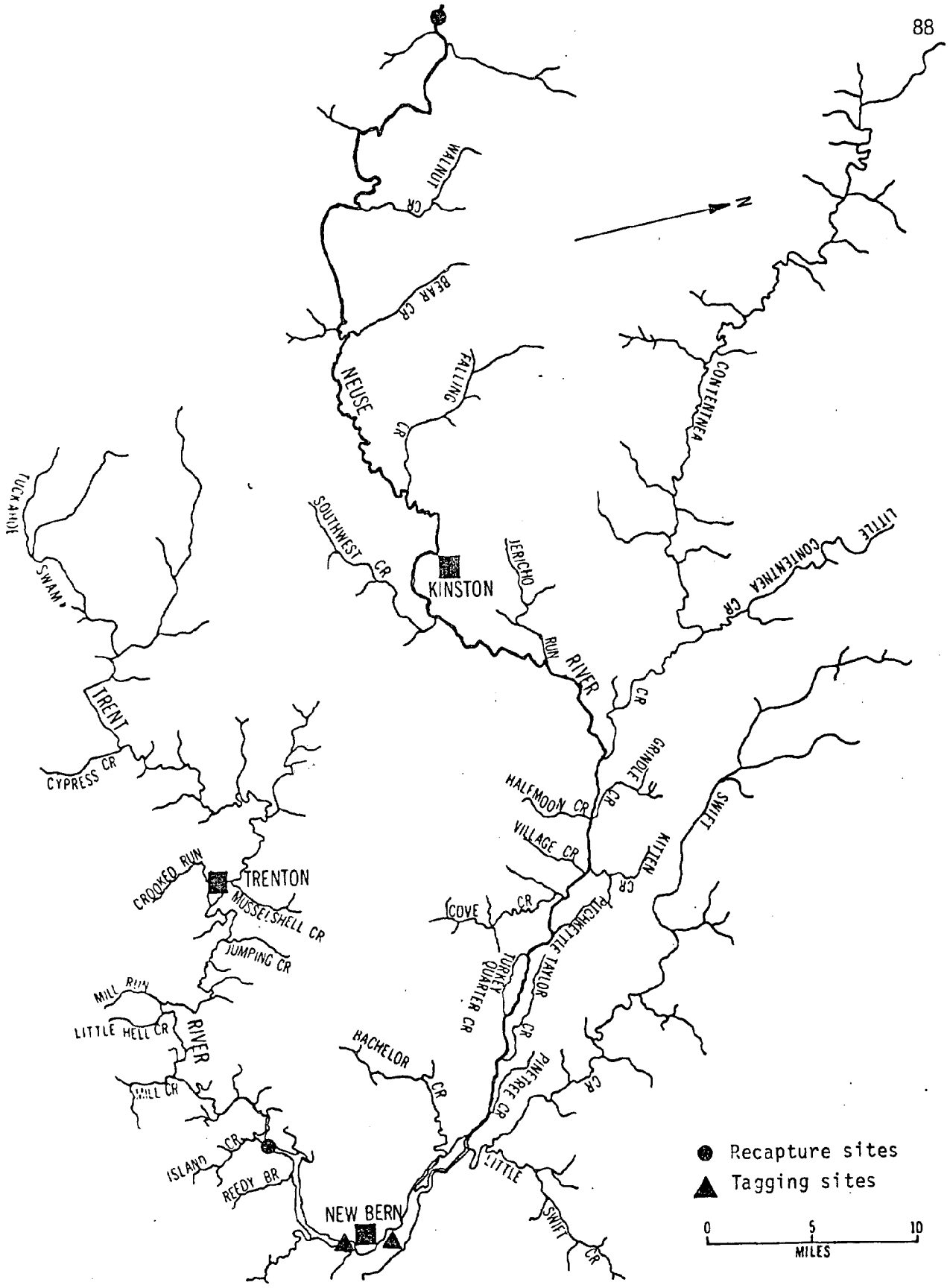

Figure 23 - continued.

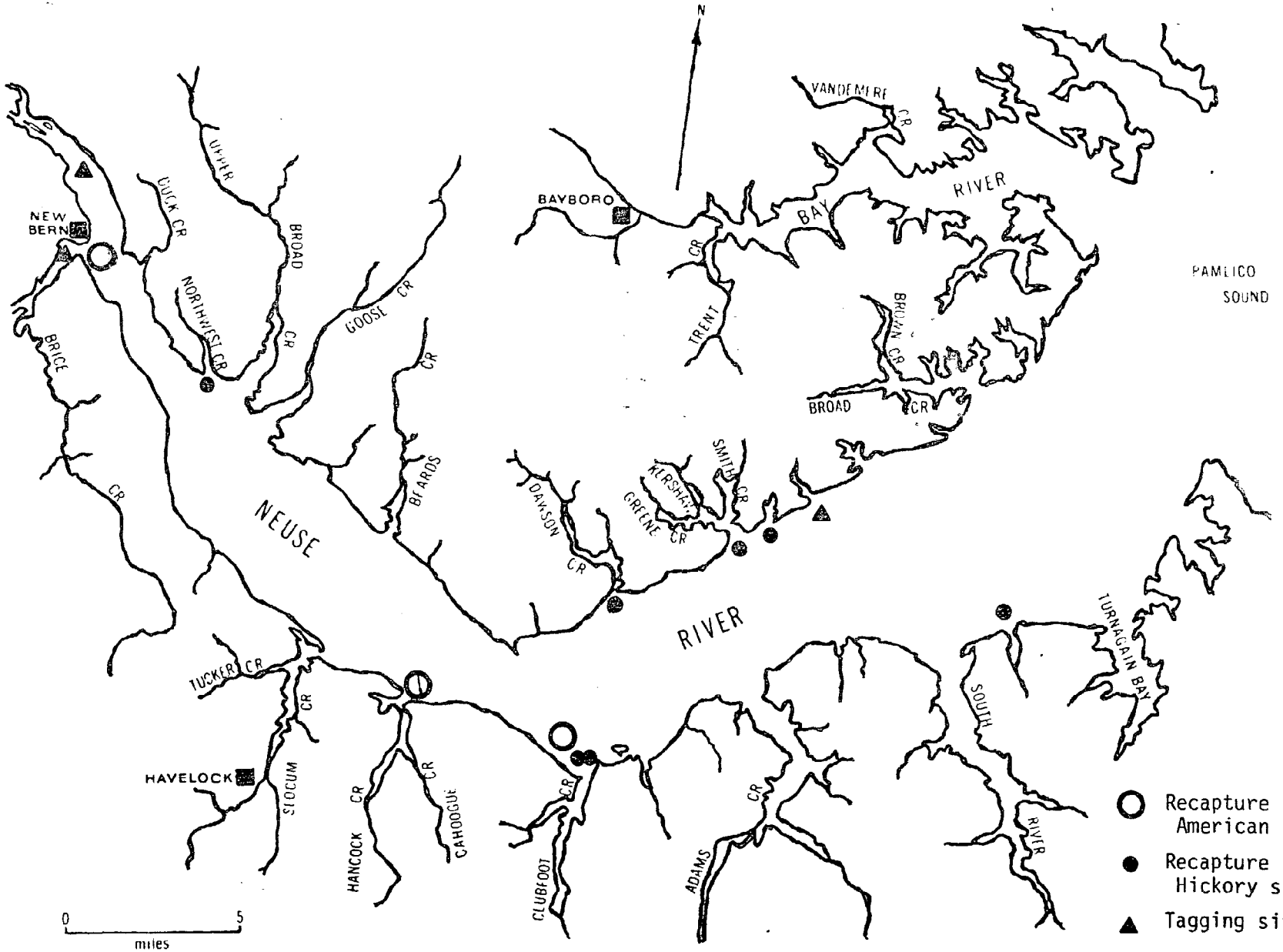

Figure 24 - Tagging and recapture sites of American shad and hickory shad in the Neuse River, NC, 1977-1979.

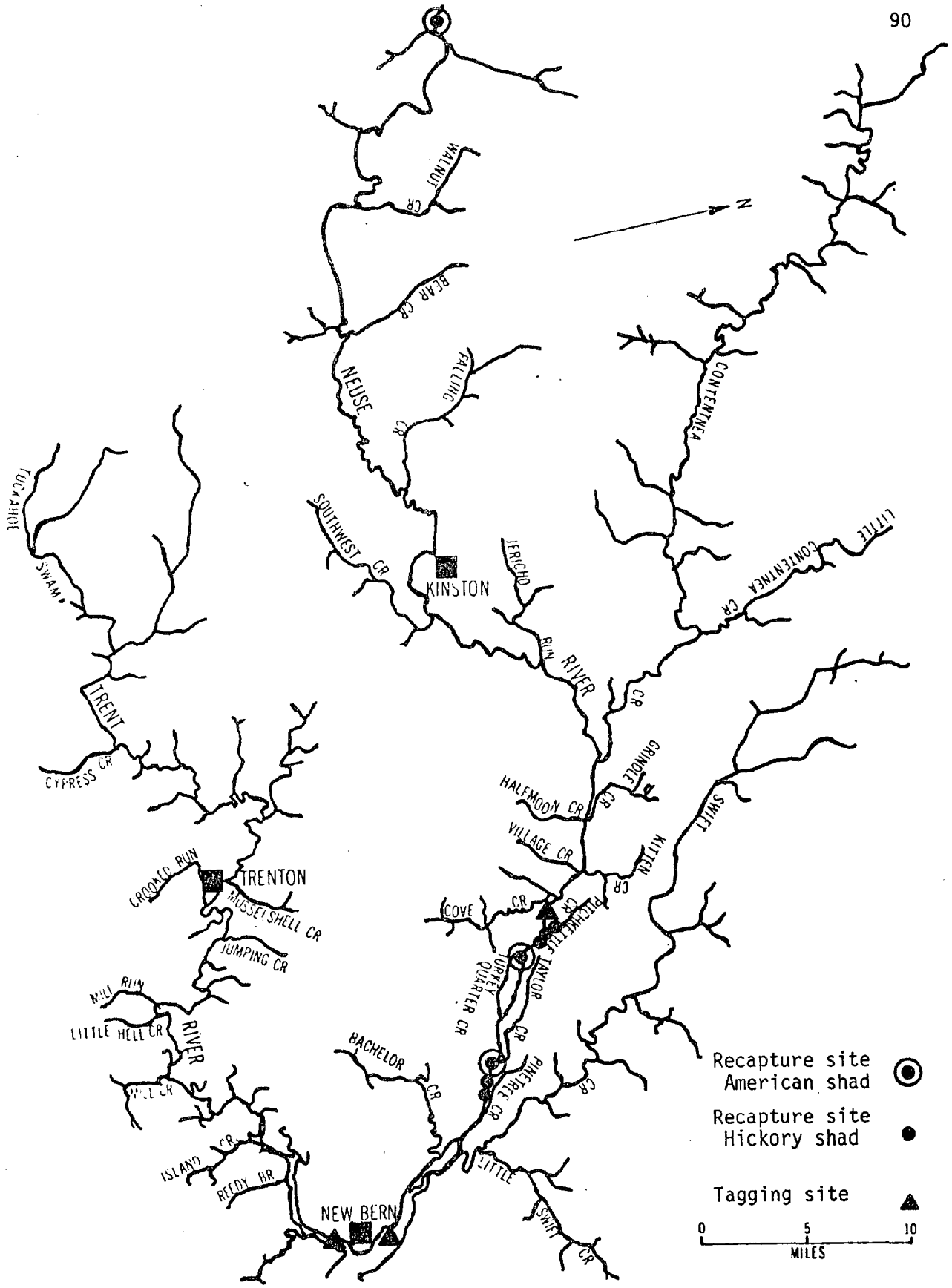

Figure 24 - continued

age range of the American shad tagged was three years to six years.

Hickory shad

Only 14 (3.6%) of the 393 hickory shad released during 1977-79 were recaptured. These returns possibly exhibit an interesting pattern in the relationship of the number of days at large and the direction and distance traveled. The seven fish that were recaptured downstream from the tagging site were all taken within nine days of tagging and traveled as far as 38 mi (56 km) downstream (Figure 24). Returns from areas upstream from the tagging sites were captured from 13-31 days after tagging and exhibited movement as far as 21 mi (34 km) upstream. This relationship may indicate that hickory shad reacted to tagging by moving rapidly downstream and later resuming their upstream migration to spawning areas. Most of the hickory shad were recaptured with drift gill nets near Pitchkettle and Pinetree Creeks and ranged from four to five years in age.

River herring

Poorest returns were received from tagged blueback herring; of the 311 tagged, only seven (2.2%) were returned. Five of the fish were recaught within a week after tagging, while the others were recaught after 15 and 26 days, respectively. Most of the blueback herring recaptured exhibited downstream movement, traveling as far as 10 mi (16 km) (Figure 25). The blueback herring tagged ranged from four to six years old.

No returns were received from eight alewife tagged.

Atlantic sturgeon

A total of 13 Atlantic sturgeon were tagged during 1977-79, of which two were recaptured (Figure 26). One young sturgeon was at large four days and traveled three miles upstream. The other was tagged in Spring, 1979, near Oriental and recaptured 49 days later close to the Outer Banks. This sturgeon had traveled at least 72 mi (116 km) when calculated with a straight line trajectory. The tagged sturgeon ranged in size from 370-700 mm, Fl.

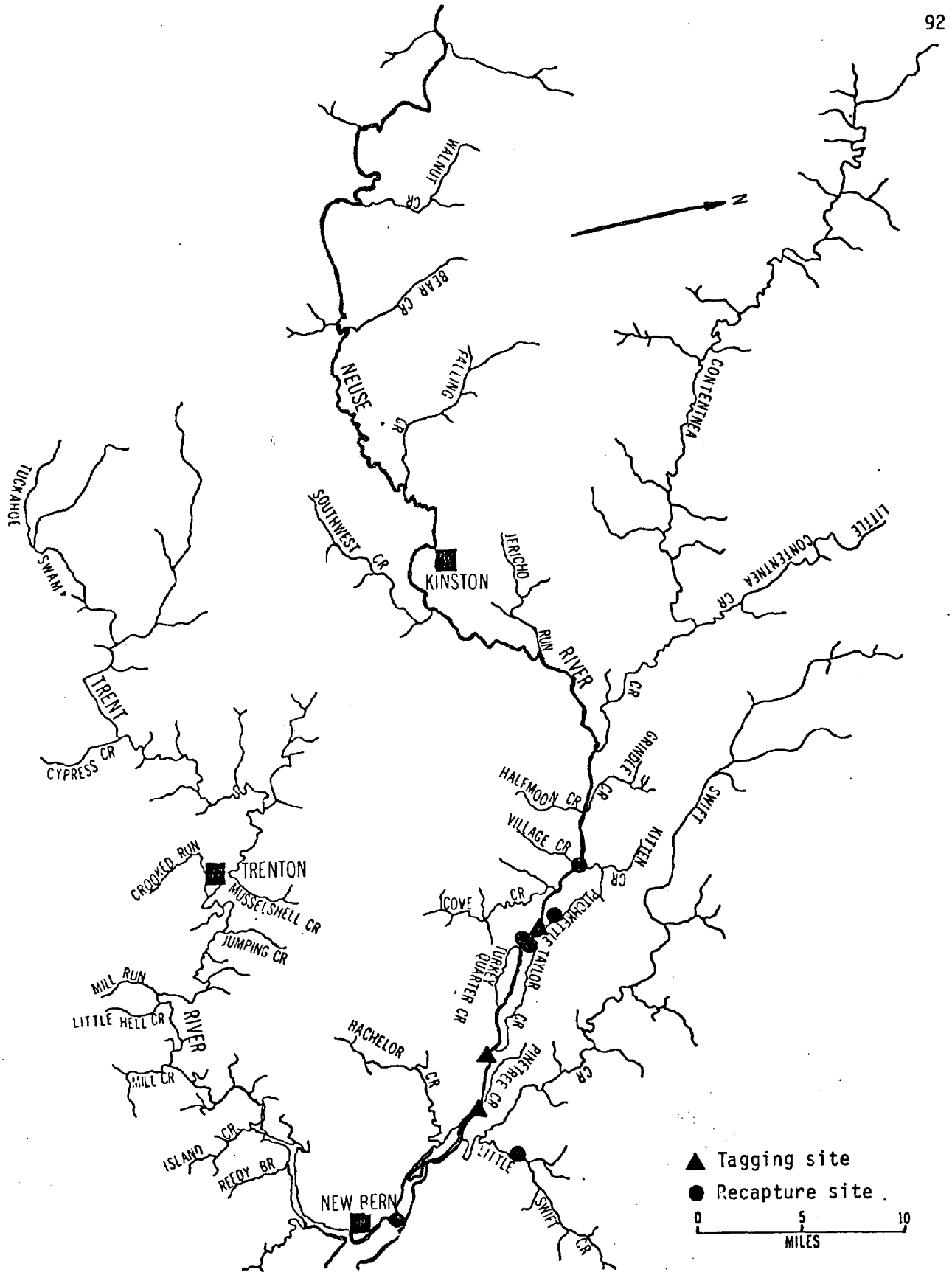

Figure 25 - Tagging and recapture sites of blueback herring in the Neuse River, 1977-1979.

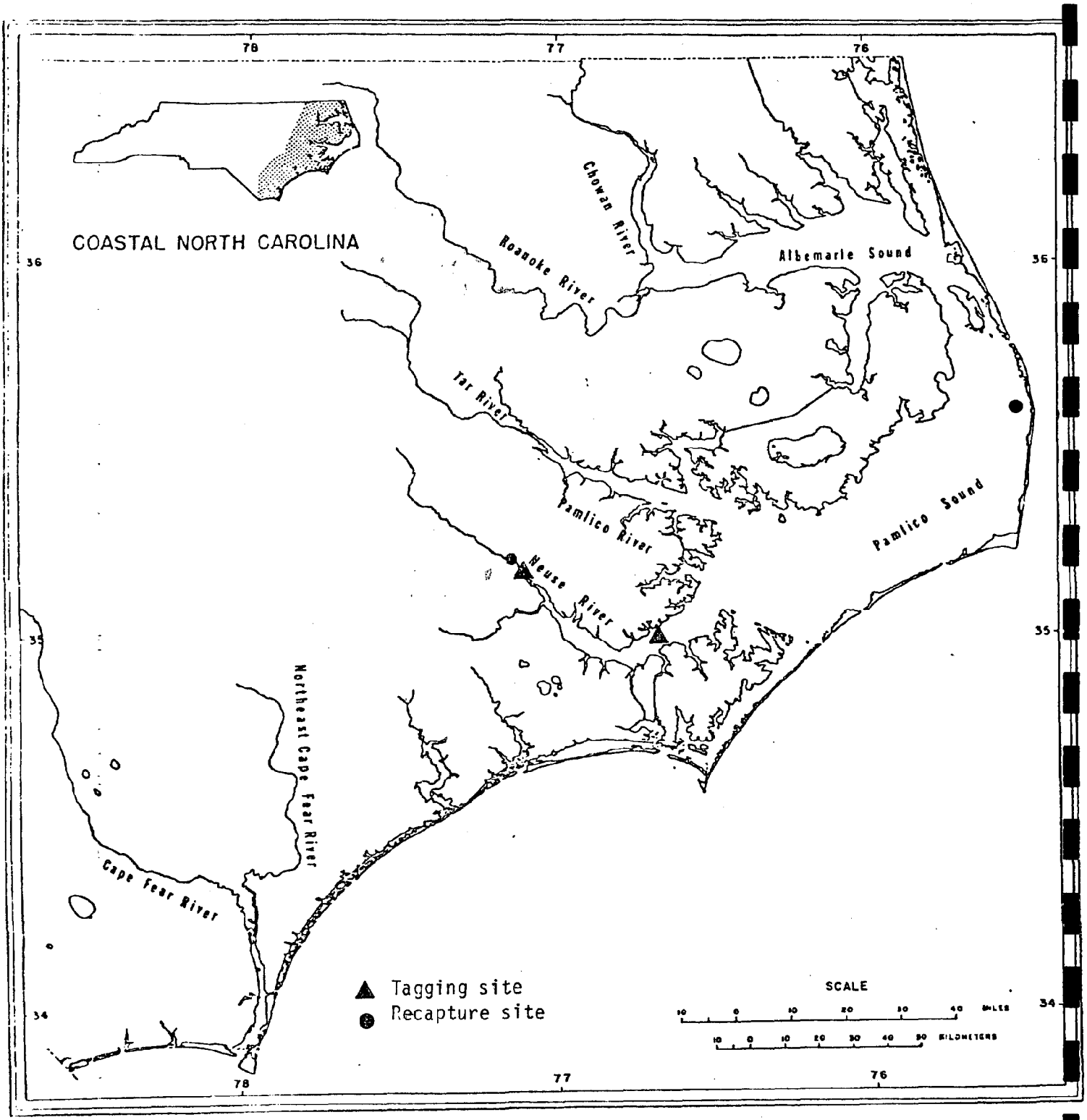

Figure 26 - Tagging and recapture sites of Atlantic sturgeon in the Neuse River, 1977-1979.

SUMMARY

1. River herring spawned in the Neuse River and tributaries from 15 March to 30 May at water temperatures of 11° - 26°C. Spawning areas were designated in the main stem from the Flowers Gap area to the SR 1700 bridge above Goldsboro. Tributaries also designated as spawning areas include Smith, Kershaw, Dawson, Hancock, Slocum, Beards, Upper Broad, Batchelor, Little Swift, Swift, Pinetree, Turkey Quarter, Taylor, Kitten, Village, Halfmoon, Contentnea, Mill, and Middle Creeks, Little River, Trent River, and its tributaries (Mill, Mill Run, and Jumping Creeks). Although no eggs or larvae were found in Cove, Grindle, Little Contentnea, Jericho Run, and Beaverdam Creeks, adults were captured in these tributaries, suggesting they are possible spawning areas.
2. River herring egg catches in 1977 and 1978 and larvae catches in 1978 appeared to be related to increases in water temperatures.
3. Channelization on Swift, Little Swift, and Bear Creeks and cropland alterations along Slocum and Adams Creeks and South River have significantly reduced river herring distribution and spawning areas in the Neuse River basin.
4. American shad spawned in the Neuse River from 31 March to 25 May at water temperatures of 11° - 26°C. The major spawning areas were located in the main stem of the river from just above New Bern to Smithfield. Eggs and larvae were also found in Trent River, Contentnea Creek, Swift Creek, Little River, and Mill Creek.
5. Hickory shad eggs and larvae were found in the main stem of the Neuse River from the NC 55 bridge at Kinston to the SR 1731 bridge at Seven Springs. Tributaries where spawning was noted include Turkey Quarter, Pitchkettle, Taylor, Halfmoon, Contentnea, and Mill Creeks, in addition to Little and Trent Rivers. Spawning occurred from 27 March to 4 May at a temperature range of 13° - 18.5°C.
6. Striped bass eggs were collected in the main stem of Neuse River from the NC 55 bridge at Kinston to the SR 1224 bridge above Goldsboro. The principal spawning area lies between the NC 55 bridge and the SR 1915 bridge a distance of 65 mi (105 km). Spawning occurred from 27 March to 30 May at temperatures

of 13.5° - 24°C. Two spawning peaks were detected and correlated with water temperatures, one at an average weekly temperature of 21.5° (9-15 April) and the other 20°C (21-27 May).

7. Although anadromous fish utilize the Neuse River above the Quaker Neck dam at Goldsboro and the Little River above the low-head dam, migration appears to be greatly hindered by the structures. Migration is mainly limited to times of high water when anadromous fish can swim over the dams.

8. Nursery areas delineated for blueback herring in the Neuse River were from the Flower's Gap area to Cove Creek and from Mill Run to Island Creek on the Trent River.

9. Growth was determined for the 1976-79 year classes of juvenile blueback herring in the Neuse River, with the 1976 and 1979, and the 1977 and 1978 year classes exhibiting similar growth.

10. Catch-per-unit-effort data indicate that the magnitude of the 1977 and 1978 year classes of juvenile blueback herring were similar, and that both were much larger than the 1979 year class.

11. Only 58 juvenile alewife were collected during 1977-79, preventing delineation of nursery areas in the Neuse River.

12. Tentative nursery areas for juvenile American shad in the Neuse River were from Duck Creek to the SR 1224 bridge above Goldsboro.

13. Juvenile American shad appeared to initiate movement out of the freshwater nursery areas of the Neuse River during October, when catch-per-unit-effort values decreased noticeably. Juvenile movement was probably affected by the unusually warm fall seasons of 1977-79.

14. The mean monthly fork length of juvenile American shad in the Neuse River was calculated for 1977-79.

15. A total of 916 juvenile hickory shad was collected during the study period; however, 905 were captured in supplemental sampling during one week in 1977. Juveniles were collected from Slocum Creek to Pitchkettle Creek. Juvenile hickory shad migration to estuarine waters apparently begins in June.

16. Only ten juvenile striped bass were collected from the Neuse River during 1977-79; four caught in 1979 were thought to be the result of a fry stocking program. The other six juveniles caught in 1978 represent the only known record of a natural juvenile stock in the Neuse River.

17. Nine young Atlantic sturgeon were collected during the study period, ranging from 370 - 700 mm in fork length.
18. Blueback herring was by far the most abundant anadromous species inhabiting the Neuse River, preferring the dark, swamp-bordered waters of the middle Neuse. Alewife preferred the higher salinity areas of the lower Neuse River.
19. Adult blueback herring ranged in age from three to eight years, with 83% of the males being four and five years old and 91% of the females being four, five, and six years old. Approximately 53% of all adult blueback herring were repeat spawners.
20. Alewife in the Neuse River ranged in age from three to eight years. Seventy-five percent of the males were four and five years old, while 66% of the females were five and six years old. Males were dominated by virgin fish, (83%), while 39% of the females were virgin.
21. Hickory shad ranged from two to eight years old, with the males dominated (75%) by three and four year old fish and the females (89%) by three, four, and five year olds. Sixty percent of the total Neuse River hickory shad sampled were repeat spawners.
22. Striped bass ranged from one to ten years old, with fish one to five years old comprising 84% of the sample.
23. American shad in the Neuse River during 1977-79 ranged in age from three to eight years. Males were predominantly four and five years old (85%) and females were five and six years old (92%). Only 7.4% of the total sample exhibited evidence of repeat spawning.
24. The major commercial fishery for anadromous fish in the Neuse River is the set gill net fishery for American shad during February-April. The fishery is selective for 430-490 mm females and 390-430 mm males.
25. The most popular sport fishing activities for anadromous fieh in the Neuse River are the hook and line fishery for hickory shad, and drift netting for American shad, hickory shad, and river herring.
26. A total of 18 striped bass were returned from 114 tagged in the Neuse River during 1976-79. Returns indicate that Neuse River striped bass have a tendency to remain in their native stream, being found most frequently in the New Bern area.
27. A total of 39 American shad, 393 hickory shad, 311 blueback herring, eight alewife, and 13 Atlantic sturgeon were tagged in the Neuse River, 1977-79. Insufficient numbers were generally returned to draw any conclusions on migration or utilization. Tagged hickory shad exhibited an apparent tendency

to travel downstream for several days after tagging and then proceed upstream to their spawning areas.

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A P P E N D I X

Table 1 - Age and spawning frequency of blueback herring sampled in the Neuse and Trent Rivers, 1977.

Spawning marks	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	24	6									24	6
IV	196	192	43	3							239	105
V	25	46	146	102	31	1					202	149
VI			1	12	39	32	6	4			46	48
VII						2	8	17			8	19
VIII						1		2		5		8
Total	245	154	190	117	70	36	14	23		5	519	335
Percent	47	46	37	35	13	11	3	7		1		

Table 2 - Size and age composition of blueback herring taken during spawning area surveys in the lower Neuse and Trent Rivers, 1977.

Age	Total number		Percent of samples		Mean fork length (mm)		Length range (mm)	
	M	F	M	F	M	F	M	F
III	24	6	5	2	236	246	225-250	237-262
IV	239	105	46	31	245	253	231-262	237-271
V	202	149	39	45	252	260	238-270	240-279
VI	46	48	9	14	260	269	242-276	257-288
VII	8	19	1	6	262	275	251-270	260-290
VIII		8		2		285		278-293
	519	335						

Table 3 - Age and spawning frequency of blueback herring in the Neuse River, 1978

Spawning marks / Age												
III	6	1									6	1
IV	58	54	6	2							64	56
V	22	16	61	43	12	3					95	62
VI			3	7	32	34	1	1			36	42
VII					1	6	2	8			3	14
VIII								1	2		0	3
Total	86	71	70	52	45	43	3	10	2		204	178
Percent	42	40	34	30	22	24	2	5	0	1		

Table 4 - Size and age composition of blueback herring in the Neuse River, 1978.

Age	Total number		Percent of samples		Mean fork length (mm)		Length range (mm)	
	M	F	M	F	M	F	M	F
III	6	1	3	1	241	250	232-258	-
IV	64	56	31	31	252	258	237-266	245-270
V	95	62	47	35	257	267	240-270	250-283
VI	36	42	18	24	264	274	255-278	261-287
VII	3	14	1	8	269	281	266-271	265-297
VIII	0	3	0	2	-	289	-	283-292
	204	178						

Table 5 - Age and spawning frequency of blueback herring in the Neuse River, 1979.

Spawning marks	0		1		2		3		Total	
Sex	M	F	M	F	M	F	M	F	M	F
Age										
III		1							0	1
IV	40	42	1						41	42
V	8	19	12	11					20	30
VI			1	8	6	8	1		8	16
VII						2	2	2	2	4
VIII								1	0	1
Total	48	62	14	19	6	10	3	3	71	94
Percent	68	66	20	20	8	11	4	3		

Table 6 - Size and age composition of blueback herring in the Neuse River, 1979.

Age	Total Number		Percent of Samples		Mean fork length (mm)		Length range (mm)	
	M	F	M	F	M	F	M	F
III	0	1	0	1	-	230	-	-
IV	41	42	58	45	246	248	230-265	230-270
V	20	30	28	32	255	263	230-295	245-290
VI	8	16	11	17	264	272	254-270	260-289
VII	2	4	3	4	270	282	-	270-300
VIII	0	1	0	1	-	300	-	-
	71	94						

Table 7 - Age and spawning frequency for hickory shad sampled in the Neuse River, 1977

Spawning marks	0		1		2		3		4		5		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F	M	F
II	12	1											12	1
III	37	63	15	4									52	67
IV	5	27	16	46	18	1							39	74
V	1	3		7	9	29	3	1					13	40
VI						4	2	6	6	1			8	11
VII								1	4	9	1		5	10
VIII											1	3	1	3
Total	55	94	31	57	27	34	5	8	10	10	2	3	130	206
Percent	42	46	24	28	21	16	4	4	8	5	1	1		

Table 8 - Size and age composition of hickory shad sampled in the Neuse River, 1977.

Age	Total number		Percent of samples		Mean fork length (mm)		Length range (mm)	
	M	F	M	F	M	F	M	F
II	12	1	9	1	294	307	272-323	
III	52	67	40	33	336	343	282-356	297-380
IV	39	74	30	36	344	357	318-368	325-392
V	13	40	10	19	356	367	335-375	321-395
VI	8	11	6	6	381	386	372-391	363-418
VII	5	10	4	5	384	415	372-392	388-440
VIII	1	3	1	1	397	411		400-421
	130	206						

Table 9 - Age and spawning frequency for hickory shad in the Neuse River, 1978.

Spawning Marks	0		1		2		3		4		Total	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Age												
III	8	14	4	1							12	15
IV	16	49	66	50	5	4					87	103
V			1	6	27	24	1	2			29	32
VI						4	4	6			4	10
VII										2	0	2
Total	24	63	71	57	32	32	5	8	0	2	132	162
Percent	18	39	54	35	24	20	4	5	0	1		

Table 10 - Size and age composition of hickory shad in the Neuse River, 1978.

	Total number		Percent of samples		Mean fork length (mm)		Length range (mm)	
Sex	M	F	M	F	M	F	M	F
Age								
III	12	15	9	9	325	338	295-352	300-357
IV	87	103	66	64	343	362	322-378	334-400
V	29	32	22	20	352	369	325-405	343-407
VI	4	10	3	6	361	403	320-400	373-420
VIII	0	2	0	1	0	403	-	390-415
	132	162						

Table 11 - Age and spawning frequency of hickory shad in the Neuse River, 1979.

Spawning marks	0		1		2		Total	
Sex	M	F	M	F	M	F	M	F
Age								
II	2	3					2	3
III	18	14	13				31	13
IV	1	2	1	3			2	5
V			1	2		2	1	4
Total	21	19	15	5	0	2	36	26
Percent	58	73	42	19	0	8		

Table 12 - Size and age composition of hickory shad in the Neuse River, 1979

Age	Total number		Percent of samples		Mean fork length (mm)		Length range (mm)	
	M	F	M	F	M	F	M	F
II	2	3	6	12	300	300	-	296-305
III	31	13	86	52	286	308	260-315	280-326
IV	2	5	6	20	345	373	340-350	345-400
V	1	4	3	16	341	384	-	377-395
	36	25						

Table 13 - Age and spawning frequency of American shad sampled in the Neuse River, 1977.

Spawning Marks	0		1		2		3		Total	
Age	M	F	M	F	M	F	M	F	M	F
III	13								13	
IV	42	24	4						46	24
V	15	176	8	16	1				24	191
VI	3	126	1	19	5	6			9	151
VII		2		4	1		2		3	6
Total	73	328	13	39	7	6	2		95	373
Percent	77	88	14	10	7	2	2			

Table 14 - Size and age composition of American shad sampled during a commercial harvest study in the Neuse River, 1977.

Age	Total Number		Percent of samples		Mean fork length (mm)		Length range (mm)	
	M	F	M	F	M	F	M	F
III	13		14		375		357-397	
IV	46	24	48	6	400	428	348-452	400-463
V	24	192	25	52	426	459	384-455	403-582
VI	9	151	10	40	441	483	420-472	430-582
VII	3	6	3	2	455	494	438-484	460-511
	95	373						

Table 15 - Age and spawning frequency of American shad in the Neuse River, 1978.

Spawning marks	0		1		2		Total	
Sex	M	F	M	F	M	F	M	F
Age								
III	3						3	-
IV	43	4	1				44	4
V	70	130	5	1			75	131
VI	8	56		2			8	58
VII		2					-	2
Total	124	192	6	3			130	195
Percent	95	98	5	2				

Table 16 - Size and age composition of American shad in the Neuse River, 1978.

	Total number		Percent of samples		Mean fork length (mm)		Length range (mm)	
Sex	M	F	M	F	M	F	M	F
Age								
III	3	-	2	0	352	-	347-361	-
IV	44	4	34	2	397	444	364-431	437-460
V	75	131	58	67	414	463	367-440	430-494
VI	8	58	6	30	423	481	408-446	448-512
VII	-	2	0	1	-	521	-	510-532
Total	130	195						

Table 17 - Age and spawning frequency of American shad in the Neuse River, 1979.

Spawning marks	0		1		Total	
Sex	M	F	M	F	M	F
Age						
IV	36	18		1	36	19
V	52	123		1	52	124
VI	12	53	1	1	13	54
VII		1		1	0	2
VIII		1			0	1
Total	100	196	1	4	101	200
Percent	99	98	1	2		

Table 18 - Size and age composition of American shad in the Neuse River, 1979.

Age	Total number		Percent of Samples		Mean fork length (mm)		Length range (mm)	
	M	F	M	F	M	F	M	F
IV	36	19	36	10	403	425	364-445	368-460
V	52	124	51	62	421	462	385-450	415-498
VI	13	54	13	27	439	482	422-470	460-513
VII	0	2	0	1	-	507	-	488-526
VIII	0	1	0	<1	-	547	-	-
	101	200						